Instruments

THE MAGAZINE OF

Measurement and Control

Vol. XIII

MAY
1940

No. 5

...a degree of control never before thought possible...

TAG CELECTRAY PYROMETERS

CLIMAX MOLYBDENUM COMPANY
OF MICHIGAN
OFFICE AND EXPERIMENTAL LABORATORY
14410 WOODROW WILSON AVENUE
DETROIT

September 21, 1938

C. J. Tagliabue Manufacturing Co.
332 E. Grand Boulevard
Detroit, Michigan

Attention: Mr. H. W. Kerr

Gentlemen:

We are pleased to comply with your request for our comments regarding the Tag Celectray Potentiometer instruments in use in our experimental laboratories.

We are using two indicating controllers of the throttling type, one in our high speed hardening furnace and the other in our lead pot, while a third indicating controller of the "on off" type is in use on our air draw furnace. All of these furnaces are of the electric type.

Your instruments have given us a degree of control never before thought possible with standard instruments. They have given us entirely satisfactory results with no maintenance cost to date.

We are also using a six point recorder of standard design on various applications in our laboratory and it, too, has proven very satisfactory. The rapidity with which this recorder comes to balance and records has made it particularly valuable in a number of special experiments.

Yours very truly,

CLIMAX MOLYBDENUM COMPANY OF MICHIGAN

Robert M. Parke

Robert M. Parke

RMP:AC

More and more, Industry acknowledges with expressions typical of this experience, that only TAG CELECTRAY Photoelectrically Balanced Pyrometers offer such precise control. With amazing simplicity of design and unusually rugged construction, these instruments guarantee unmatched low maintenance expense and notable operating facility.

Today, the CELECTRAY Throttling Controller provides an economical means for throttling electric heat with no other equipment than is ordinarily used for on-and-off control . . . Employing the CELECTRAY principles of photoelectric detection of the position of a light beam reflected from a mirror galvanometer toward a reciprocating controlling edge, this Controller has no dead zone and holds a steady temperature without oscillation.

You'll find the same accuracy and instantaneous action in CELECTRAY Recording Pyrometers. The TAG method of photoelectrically balancing a potentiometer or Wheatstone bridge means higher recording accuracy, increasing the value of the CELECTRAY as a precise electrical instrument. The complete line of CELECTRAY Pyrometers includes models for Indicating, Recording and Controlling. Get the whole story on these favored precision tools. Learn what they can do for you in terms of lowering operating expense and raising product uniformity.

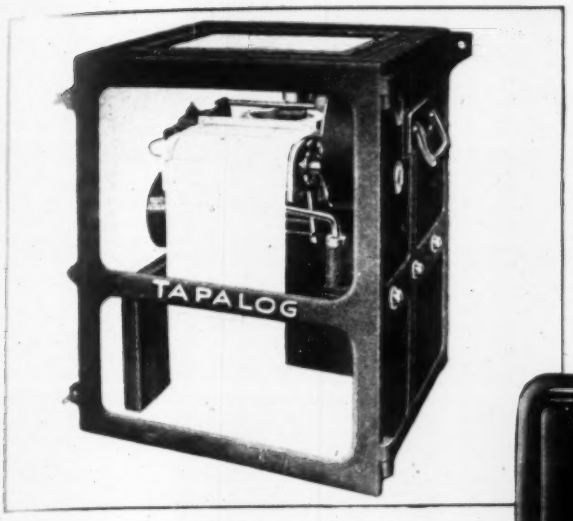
As an evidence of continued high performance and low maintenance expense with TAG CELECTRAY Pyrometers, it is interesting to note that the Climax Molybdenum Company has purchased 9 additional CELECTRAY Throttling Controllers and 1 additional CELECTRAY Recorder since receiving their testimonial.

TAG TAGLIABUE

C. J. TAGLIABUE MANUFACTURING CO.,

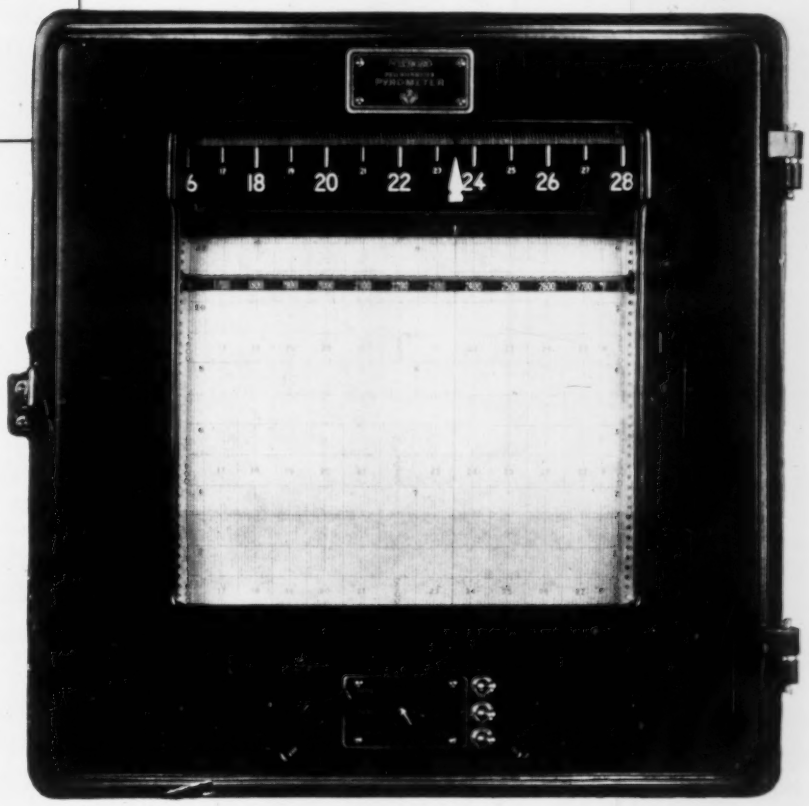
Park and Nostrand Aves., Brooklyn, N. Y.

U. S. TAGLIABUE MANUFACTURING CO.
PEN and SQUARE Sts., BROOKLYN, N. Y.



First in 1914

The Tapalog — first multiple recording pyrometer built in the United States. Its *practical performance* under actual conditions of plant operation set a course for a quarter-century of progress in industrial pyrometry.



First Choice in 1940

Foxboro's latest achievement in the same "*practical performance*" tradition — a pyrometer-controller with indicating and recording functions — a clear "first" in sensitivity of detection, in flexibility of control action, and in adaptability to critical furnace conditions or processing requirements.

Over the past quarter-century, metallurgical progress and advancements in pyrometry have been so closely allied – so inescapably interdependent – that it has become impossible to separate their respective contributions to industrial achievement and modern ways of living. Thus, without attempting to isolate its own part in the advance, Foxboro takes pride in its continuous association with those who have taken the lead in improving metallurgical techniques, in raising the properties of metals and lowering the costs of manufacture.

After all, an "improved" instrument cannot be designed in a vacuum – it must lead to a practical advance in its intended industrial application, or stay on the shelf. The way to verify instrument progress, then, is not by the additional intricacies within the case, but by the improved performance of well instrumented plants. That is why Foxboro knows no better evidence of its own achievement than the fact that, in plants throughout the nation, new advances in metallurgy are continually being made because of the higher standards of accurate measurement and precise control which Foxboro instruments have made available. **The Foxboro Company, 46 Neponset Avenue, Foxboro, Mass., U.S.A.** Branch Offices in 25 Principal Cities.

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RECORDING | CONTROLLING · INDICATING
Instruments
Certified ACCURACY RESPONSE
TEMPERATURE · LIQUID LEVEL
PRESSURE · FLOW · HUMIDITY

The Latest in CONDENSERS

Plug it in!

● Developed primarily for the U. S. Signal Corps and for use in aircraft-radio, police-radio, sound-system and other equipment where *continuity of service* is a prime requisite, the new Aerovox Plug-in Electrolytic Series AP opens up untold possibilities.

Readily removed, tested, replaced, these perfected octal-base electrolytic condensers handle as easily as a radio tube or vibrator. Assemblies can be equipped with fresh plug-in electrolytics immediately prior to shipment or to actual use. Users can have "spares" on hand. The many problems encountered in providing a tight, leak-proof, hermetically-sealed octal base, together with positive elimination of corrosion, have been fully solved. You are offered a perfected product.

Write for DATA . . .

● Engineering data on this Series AP Aerovox Plug-In Electrolytic Condenser will be sent on request. Also samples, specifications, quotations, to responsible parties.

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NEW BEDFORD, MASS.
IN CANADA: AEROVOX CANADA, Limited Hamilton, Ont.

Instruments

THE MAGAZINE OF MEASUREMENT and CONTROL

Vol. XIII MAY 1940 No. 5

FRONT COVER: Blast furnace control panel, Carnegie Furnaces, Carnegie-Illinois Steel Corp., Rankin, Pa. Courtesy Leeds & Northrup Co.

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THE MAGAZINE OF
Measurement and Control

F. BEHAR, Editor

"Coördinatographs"

FOR lack of a more easily pronounced name, this jaw-breaker is used as a title. It is the generic designation (provisional, we hope!) of a group of recording instruments deserving a better name because they deserve your thoughtful consideration. These recorders may be roughly defined as those which produce "*x-y*" diagrams. As a rule, a coördinatograph has a single pen and its function is to plot automatically the mutual values of two measurables, neither of which is time.

Oldest and most familiar example in engineering is the ordinary engine "indicator" which produces a pressure-volume diagram.

An example in physical testing is the autographic stress-strain recorder which produces a load-deformation curve.

An example in chemistry is the "Polarograph" which produces the current-voltage curve for the Heyrovsky method.

In acoustics there are automatic analyzers which plot decibels *vs.* frequency.

In electric power transmission engineering there is the Allen and Gross Equipment which produces frequency *vs.* current peak charts for locating faults.

Most spectacular of all, perhaps, is Professor Ralph Muller's spectral-distribution color analyzer which produces a wave-length *vs.* relative energy curve in 1/20 second.

In these six examples we have twelve different measuring elements and eleven different methods of displacing a pencil, a pen, a drum, a light spot or a cathode-ray spot. The only example where the same method is used for "*x*" and for "*y*" is the last one, in which electrostatic deflection is used for both. But even in a cathode-ray oscillograph two different methods could be used, the second being magnetic. Indeed, there are not merely an even dozen different methods, but perhaps more than twenty. Some of these are old. Examples, both the piston-and-lever and the string-and-drum of the classical engine indicator. Some are new. Examples, both the e-m. and e-s. methods of deflecting a pencil of electronic bullets. A few methods are well-known; more are little-known.

Our special purpose is to call attention to the possibilities opened up by the development of thoroughly reliable relay, follow-up and servo-motor devices, such as are successfully employed in self-balancing bridges and potentiometers, in telemetering systems and in automatic-control systems. These mechanisms are capable of moving a pen or other marking device all the way across the chart in a few seconds—or in less than a second—without causing the record to deviate appreciably from the instantaneous values of the recorded magnitude—even when the unamplified available power of the utilized effect is of the order of micro-microwatts. Well, then, why not use any one of these perfected and commercially-available mechanisms to position the chart drum according to the value of "*x*" while another measuring-and-operating system positions the pen in the familiar way, according to the value of "*y*"?

It sounds easy. It *is* easy.

Too often, for lack of acquaintance with this possibility, an order is placed for a two-pen or two-point recorder—or even for two recording instruments—when the real requirement is not for a time record but for an "*x-y*" diagram. We recently came across such an installation. It was explained to us by a friend who displayed pride in his solution. When we began to talk about simultaneous "*x-y*" diagrams he cut us short scornfully, asking "How in heck could you use either an engine indicator or an oscillograph?"

We suddenly remembered J. E. Allen's article in our March 1936 issue and asked him to look it up. He reached for his 1936 volume, found the place, took a glance at the photograph on page 69, and exclaimed "Why, that apparatus must have cost five or ten thousand dollars!"

"If it did," we replied, "only a small fraction of this cost was represented by the measuring system and chart drive whereby frequency is substituted for time. Anyway, my contention is that you *can* have your chart continuously re-positioned by *either* of your two variables instead of by a clockwork."

And so, perhaps, can *you!*

The 1941 Instruments Index

YEAR after year every effort is made to perfect THE INSTRUMENTS INDEX which constitutes Part Two of the January issue. Since nothing human can attain absolute perfection, it is realized that the methods of classification, etc., could be improved. You who use the Index are best able to suggest improvements. Please send in your suggestions.

A.S.M.&C. Elects Pigott

PITTSBURGH, April 30—The American Society for Measurement and Control announces that the Election of Officers, at its meeting held April 29, 1940 in the Auditorium of the U. S. Bureau of Mines, Pittsburgh, resulted in the unanimous election of the slate submitted by the Nominating Committee headed by L. M. Susany, Power Engineer, Carnegie Institute. The new officers are:

President—R. J. S. Pigott, Head Engineering Dept., Gulf Research & Development Co., Harmarville, Pa.

Vice-Pres.—M. F. Behar, Editor, *Instruments*, Pittsburgh.

Secretary—Frank C. McGough, Instrument Engineer, Weirton Steel Co., Weirton, W. Va.

Treasurer—Clarke E. Fry, Head Instrument Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Director—M. D. Johnson, Chief Inspector, Caterpillar Tractor Co., Peoria, Ill.

Director—J. B. Keller, Chief Instrument Engineer, Carnegie-Illinois Steel Corp., Clairton, Pa.

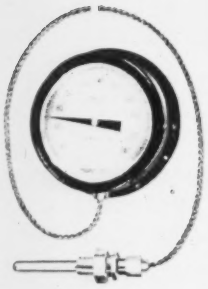
Reginald J. S. Pigott was graduated from Columbia University (Mechanical Engineering) in 1906. He is a member of the A.S.M.E., A.I.E.E., A.G.A., S.A.E. and A.P.I. He holds or has held office in some of these bodies. From 1913 to 1915 he was a member of the Power Generation Committee of the A.I.E.E. also of Power Generation Committee of the A.E.R.A. From 1916 to date he has been Chairman of the Special Research Committee on Fluid Meters, A.S.M.E.; Chairman, Main Research Committee, A.S.M.E.; member, Main Power Test Codes Committee, A.S.M.E. and Chairman of two of the sub-committees; member, A.S.M.E. Special Committee on Symbols and Abbreviations. He is the author of numerous papers on power plant design, flowmeters, lubrication, etc. His professional work has ranged from designing precision instruments to designing huge power plants, from teaching engineering to managing manufacturing establishments.

MOELLER
PRECISION GRADE INSTRUMENTS

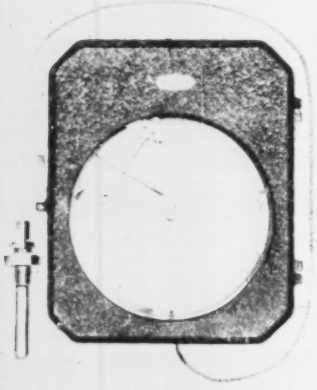
★

Moeller mercury thermometers are made with the Moeller Glass Red Reading Column making them easy to read under varying light conditions, at a considerable distance and over a wide range.

★



Moeller dial thermometers are made in various scale ranges up to 1000°F. or equivalent. Metal and Phenolite cases.



Moeller recording thermometers are likewise furnished in various ranges up to 1000°F. or equivalent. Round and square cases as preferred.

Also HYGROMETERS
RECORDING PSYCHROMETERS
BAROMETERS HYDROMETERS
MARINE INSTRUMENTS, ETC.

Write for catalog.

MOELLER INSTRUMENT COMPANY
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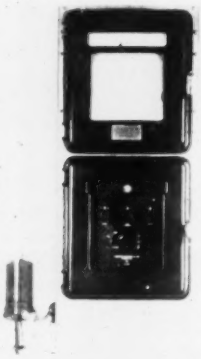
RICHMOND HILL NEW YORK

Sales Representatives in Principal Cities

THE MONTH'S NEW INSTRUMENTS

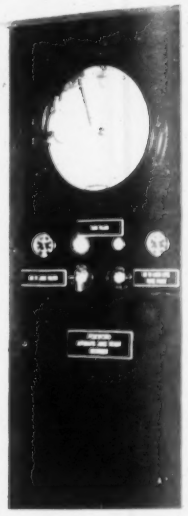
In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

Industrial pH Recorder



New "Cambridge" Thermionic pH Recorder has been designed for industrial applications. Installation consists of (1) electrode assembly and (2) combined potentiometer-recorder. Former may be several hundred feet from latter. Glass electrode voltage is balanced potentiometrically by means of the thermionic potentiometer and recorded in pH values. Operation of potentiometer from 110-125-volt a-c. source is said to obviate uncertainties of battery operation. Recorder has 10" chart which provides ½" for each 0.1 pH (smallest division). Standard chart speed is 1" per hour; others available. Electrode system features measuring electrode consisting of a rugged membrane of electrode glass. Reference electrode consists of a permanently-filled calomel electrode. Junction to test sample is made by saturated KCl solution through ground glass plug. Resistance thermometer provides automatic temperature compensation. Continuous-flow chamber is so designed that no clogging is caused by solid particles carried in sample solution. Weatherproof, housing permits electrode installation out of doors.—*Cambridge Instrument Co., 3-3, Grand Central Terminal, New York City.*

Juice Measurement System



New automatic juice measurement system provides a daily record of raw juice flow, accurate within 0.1% regardless of specific gravity, is easily installed on process out tanks, operates without manual adjustment or supervision. System does not actually weigh juice in pounds, but measures, controls and records the head of juice in a calibrated tank. It directs flow from grinder to one measured tank after another, automatically filling them to a calibrated level, and when emptying them, meanwhile making a chart record of each filling-emptying cycle. As standard tankful weight has previously been determined, no record-keeping is involved except, at end of day's operations, to multiply this known weight by number of tankfuls shown on chart. Any number of tanks can be used, filling and dumping in rotation. A separate system is required for each grinder and its dependent tanks. Operating principle: a constant stream of air, delivered at constant pressure to an open-end pipe immersed in the juice, meets an increasing back-pressure as juice level rises, until, at predetermined level, back-pressure causes operation of controlled valves.—*The Foxboro Co., Neponset Ave., Foxboro, Mass.*

Lubricated-plug Cock for Gage Lines

To provide a leakproof wrench-operated gage cock which can be completely opened or closed with ¼ turn, makers have developed a lubricated type for test pressures up to 6000 lbs. in.². It has a 2000-lb. rated working pressure for water, oil and gas. Body is forged steel, plug is stainless steel. Stick lubricant is inserted under a lubricant is inserted under a lubricant screw which, when turned down, transmits hydraulic pressure to seat, so that in event cock becomes hard to turn, pressure exerted will loosen it. Special lubricants are available for steam. New gage cock is made in ¼" and ⅜" sizes.—*Hoke Needlestem Valve Co., 500 Lexington Ave., Pittsburgh, Pa.*

Film Dryer

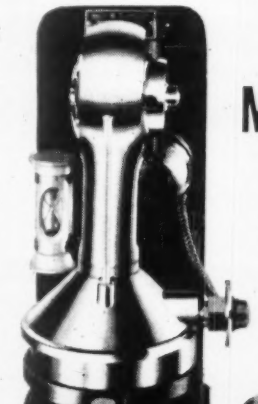
Supplementing maker's larger types, new "Model D" electrically operated film dryer may be set on a bench or table, or hung on darkroom wall. No installation is required other than plugging into light circuit (six models are available, for various voltages and frequencies) and for deck. Capacity is twelve 14"×17" films. Air is drawn in at top, electrically-heated, blown down through dryer, and exhausted at bottom. Construction is all-steel.—*General Electric X-Ray Co., 2012 Jackson Blvd., Chicago, Ill.*

FLAME-OTROL
Combustion Safeguard
FOR ANY KIND OF FUEL

An actually fool-proof, instantaneous operating combustion safeguard that not only shuts off the fuel supply to the burner upon flame failure, but safeguards against interruption in its own electrical system, grounding of electrode and other dangerous conditions. It is non-mechanical—a radio impulse does the work.

Write for complete details.

Wheelco Instruments Co.
1929-33 S. HALSTED STREET · · · CHICAGO, ILLINOIS



★ **Moisture Teller** ★

Rapid and accurate moisture test in percentage by drying. Drying temperature controlled by thermostat. Ideal for plant moisture control or laboratory moisture determinations.

Time required to dry the majority of materials is one minute.

Suitable for granular—fibrous—crystaline materials in industries such as:

Sand—Textile—Tobacco
Ceramic—Rubber—Food
Wood—Mining—Leather

Write for Literature

Harry W. Dietert Co.
9330-C Roselawn Avenue
Detroit, Michigan

Inductor-type Dynamometer

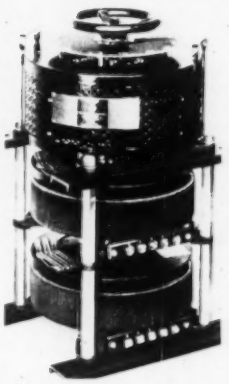
New inductor-type dynamometer for engine testing is said to possess same high-torque accuracy characteristic as maker's d-c machines; though less than half as large as latter, is rated 600-hp. as compared with 300-hp. rating the d-c dynamometer. Claimed advantages are accurate torque indication, low maintenance, compact design, and ease of operation. Control involves a main field rheostat and a vernier rheostat for control of torque and speed. These regulate current to field coil as in a d-c machine. Also provided are a push-button-operated line contactor for d-c. supply, and an ammeter and voltmeter for field circuit. If prime mover is an internal-combustion engine, interlocks cut off ignition in event of too high a temperature due to failure of water supply, or failure of excitation.—*General Electric Co., Schenectady, N. Y.*

Extreme-precision Bourdon Tube Gages

Previously made only as standard equipment on hydraulic testing machines, pressure gages of large dimensions (8½", 10", 12" and 16" dials) and of extreme precision are announced for general sale. These commercial models embody new refinements (some recently patented) in design, heat-treatment, construction and methods of manufacture and calibration. Guaranteed accuracy is 0.5% *of reading* for all loads above 20% of gage capacity. Each gage is individually graduated and accompanied by a certificate of calibration at twenty points on its scale.—*Heise Bourdon Tube Laboratories, 275 Noble Ave., Bridgeport, Conn.*

Manual Voltage Regulators for Three-phase Operation

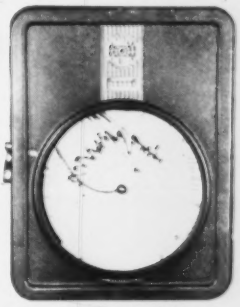
"Type 50 Variacs" (5 kw. size) can now be provided in 2- and 3-gang combinations for use on three-phase circuits, and with current equalizing chokes for parallel operation on single-phase circuits. Both 115- and 230-volt models are available. The 230-volt, 3-gang unit can be used in wye connection on 560-volt circuits to obtain continuously-variable output voltages from 0 to 560 volts with a maximum output of 30 kva. Because the Variac is an autotransformer, internal power losses are negligible. Illustrated is a three-gang assembly of "Type 50-B" Variacs. Ganged assemblies are supplied for table mounting unless otherwise specified. Net weights, two-gang, 175 lbs.; three-gang, 250 lbs.—*General Radio Co., Cambridge, Mass.*



BAILEY METERS

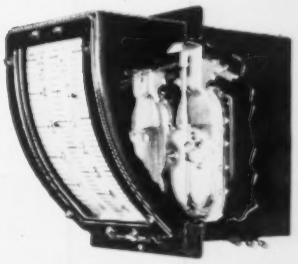
METERS and CONTROL *for Boiler Room Service . . .*

Boiler Meters Reduce fuel costs, lessen maintenance and outage, lower standby costs, and add capacity. They indicate, record and integrate Steam Flow from the boiler, record Air Flow supplied for combustion and record Flue Gas Temperature.



Bailey Boiler Meter

Multi-Pointer Gages for indicating drafts, pressures, differentials are available with any number of pointers from one to twelve. They are actuated by sturdy yet sensitive diaphragm units.



Multi-Pointer Gage

Flow Meters. For indicating, recording and integrating the flow of steam, feed water, compressed air and other fluids.

Coal Meter

Granular Material Meters For accurately measuring the flow of coal or other granular materials in gravity chutes from overhead bunkers. The total quantity of granular material is shown on a large illuminated counter which may be easily read at a distance of 50 feet.

Control Systems Make possible the every-day operation of equipment for steam generation and utilization at test efficiencies. They are applied to the control of combustion, feed water, superheat, desuperheat and other factors.

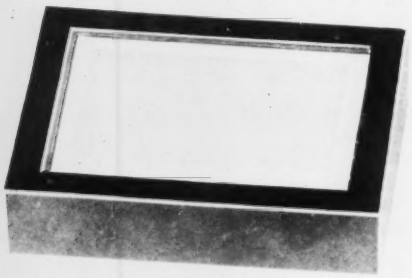
Complete Information on any of the above Bailey products will be gladly furnished upon request.

G-14

BAILEY METER • COMPANY •
1041 Ivanhoe Rd., Cleveland, Ohio
BAILEY METER COMPANY LTD., MONTREAL

Replica Diffraction Gratings

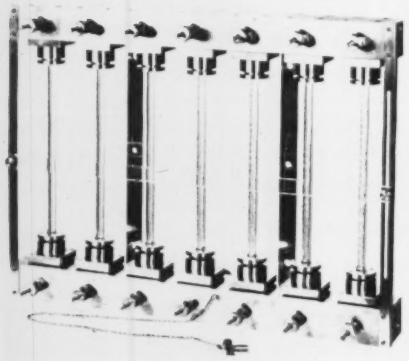
Replicas of master diffraction gratings by Dr. Robert W. Wood (14,400 or 1,813 lines per inch) are available in various sizes from ½" sq. to 150×100mm, ruled sur-



faces, in various mountings, in "elementary" or "advanced" type and in two grades. The twenty models listed in maker's announcement range from students' gratings at $20 a dozen to research gratings. It is stated that "by actual photometric measurement the Wood Grade 'A' replicas consistently give, in the first-order spectrum with the 14,400 rulings, nearly four times the intensity of any other replicas commercially available." This is said to be by reason of improvements in Dr. Wood's new master gratings and improvements in the technique. *W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago, Ill.*

Multiple Rotameters

Assemblies of two or more Rotameter flow-rate indicators are announced. Fittings are made from square bar stock arranged so that assembly can be fastened directly

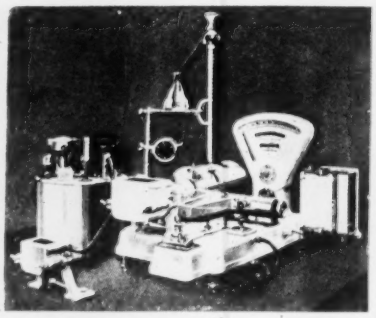


against a panel board. Needle type combination control and shut-off valves are built into bottom fitting; plain shut-off valves into top fitting. Each flow-indicating unit can be isolated, or can be individually removed for cleaning. A Lucite indexing scale aids operator to maintain all floats at same height after adjusting individual needle valves. *Fischer & Porter Co., 116 West Penn St., Germantown, Philadelphia, Pa.*

Photoelectric Color Comparator

New "Pho-Tron Colorimeter" employs for light source a standard 6-volt bulb controlled by manually-operated voltage regulator; for photoelectric receiver a "Photronic" cell; for cell-output measurement a vernier potentiometer. A standard 2" filter is interposed between solution cell (standard 1cm). Nesbitt and photocell. Light source is standardized by measuring its intensity, to compensate for gradual deterioration, etc. Readings are obtained from calibrated dial of potentiometer. These values represent light absorption by solution being measured, and are referred to a previously prepared chart, from

PLASTOGRAPH



Recording Plastometer—based on the dynamometer principle and practically "weighing" the plasticity of the different materials. Measures consistency over a wide range of materials—from fairly viscous, syrupy substances to unvulcanized rubber. Has been applied successfully in RESEARCH as well as in PLANT CONTROL (for continuous operation) in the following industries:

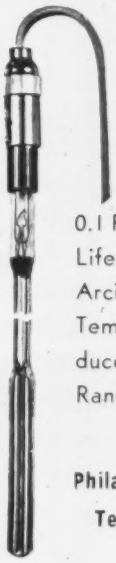
RUBBER — CELLULOID — ARTIFICIAL SILK — PHOTOFILM — ACTIVATED CARBON — PAINT — FERTILIZER — STARCH — DEXTRIN AND GLUE — TAR — ASPHALT — As well as for TESTING OF SOILS for Highway Building . . .

Can be supplied with various types of mixers or agitators—all water jacketed for efficient temperature control. Has three different sensitivity settings and can measure and record within each desired range with three times and five times increased sensitivity by the simple expedient of zero-suppression.

Pamphlet on Request

BRABENDER CORPORATION
ROCHELLE PARK, N. J.

Philadelphia Merc-to-Merc Thermo-Regulators Feature



Mercury to Mercury Contacts : Increased Contact Capacity : Sensitivity within 0.1 F. Exceptionally Long Life and Stability : No Arcing : No Oxidation : Temperature Lag Reduced : Temperature Ranges to 700° F.

●

Philadelphia Merc-to-Merc Temperature Controls

●

The Philadelphia Thermometer Co.
915 Filbert Street -:- Philadelphia

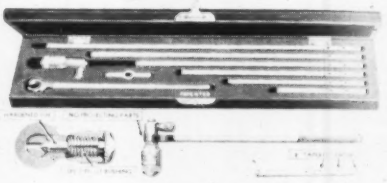
Oldest Thermometer Manufacturer in Philadelphia

Midget Capacitors

For applications calling for high [illegible] values at low voltages, midget [illegible] electrolytic capacitors are announced. [illegible] capacities from 1000 to 3000 mfd., [illegible] working voltages of 6, 12 and 15. *[illegible] Corp., New Bedford, Mass.*

Inside Micrometer

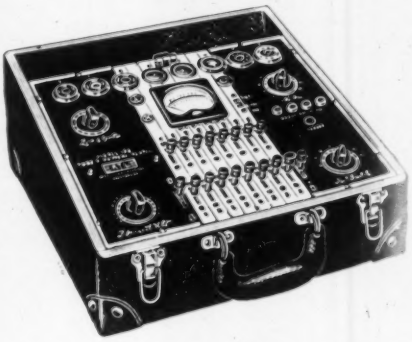
Among features of new "International Inside Micrometer" is quick setting to different ranges, due to method used in [illegible] ing measuring rods, each of which is



to micrometer head by means of a locking screw which screws into a center into a center on the rod. Centers are easily [illegible] cated. All rods have three centers, [illegible] rately spaced ½" apart, giving a range of 1½" to each rod, minimizing rod changing. Centers continue through rod and are [illegible] kept clean. Extra-long extension handle [illegible] quickly and easily attached to micrometer head, can be used in blind holes, etc. [illegible] set (1½"—6" and 12"—12") is packed in [illegible] hardwood case. *Pacific Specialty Co., [illegible] N. Vermont Ave., Los Angeles, Calif.*

Tube Tester

In new "Model 120," the PMT operation circuit switching is designed to accommodate any possible combination of heater and control elements of all existing



sockets, "and for all tubes that may be introduced in the future." Stock switches are used throughout, thereby minimizing cost. Three d-c. ranges, 0-10-100-1000 volts, are available for testing of batteries and d-c power supplies. New tester is available in two models: counter (sloping metal case with a slide drawer to hold the tube chart) and portable-mounted in leatherette case. *The Eubanchank Laboratory, 1328 Sherman Ave., Evanston, Ill.*

EBY

BINDING POSTS

PHOTO CELLS

SENSITIVE RELAYS

MOLDED INSTRUMENT SOCKETS

TIP JACKS

MOLDED BAKELITE PARTS

METAL STAMPINGS

LAMINATED BAKELITE STAMPINGS

CONNECTORS

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Adequate facilities for Complete Assembly Work Storage—Packing—Shipping

HUGH H. EBY, Inc.
4700 Stenton Avenue
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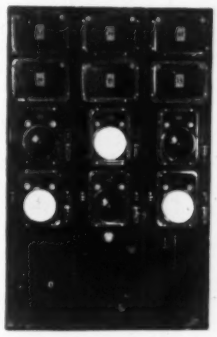
FALSTROM



STEEL PANELS

FALSTROM Precisioned Steel Panels are specified by engineers for their Strength . . . Durability . . . Fine Appearance . . . for use in—

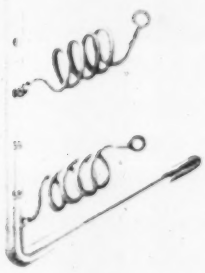
POWER PLANTS
OIL REFINERIES
PUBLIC UTILITIES
PROCESS INDUSTRIES
COMMUNICATIONS

Send blueprints. Write for bulletin P-5

FALSTROM
COMPANY of PASSAIC N. J.

Short-range Thermometers with Control Electrodes

New "Philadelphia Visual-Stats" have been designed for extremely close control of temperature, as in viscosimeter baths, crystal-oscillator enclosures, etc., are available in angle form (illustrated) or straight form. Unusual feature is that electrodes sealed in capillary bore terminate on back of tube (no bands around tube). Thereby making entire scale legible. Capillary bores being fine, each instrument has its short range, with half-degree-etched graduations, and control sensitivity of 0.01° F. These new instruments are designed to be used with maker's "Adlake" mercurial-type relays; this combination has operated more than 2½ million times without failure in a recent test.—*Philadelphia Thermometer Co., 915 Filbert St., Philadelphia, Pa.*



Kilovoltmeter Multiplier

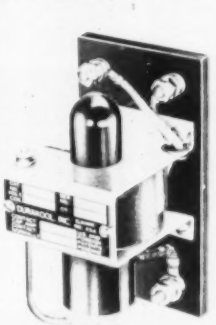
New "U-765 Kilovoltmeter Multipliers" are high-resistance boxes designed for use with a variety of instruments for measuring potentials. Model illustrated consists of

Illustration—See manufacturer's advertisement on this page

a low-potential voltmeter connected with a high resistance (the multiplier) which permits connections across a high-potential line for making voltage measurements. In many cases prospective users have suitable measuring instruments and therefore only need the multiplier. It is said that from the safety standpoint there is an excellent distribution of voltage, that the multiplier is not affected by humidity, and that it functions equally well on a.c. or d.c. Unit can be made portable or can be permanently installed.—*Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.*

"Unbreakable" Mercury Relay

New "Durakool Mercury Relay" combines maker's unbreakable metal-body mercury switch with solenoid actuation. Contact structure is hermetically sealed, making relay suitable for use in corrosive or explosive atmospheres. Relay may be operated up to 300 times per minute. It is said that there is little friction and no wear in operation. Contact resistance is as low as 0.002 ohm. On a.c., as little as 1 watt is required for normal closing operation; 1.5 watts for normal opening operation. On d.c., 0.25 watt. Relay is also available for special requirements up to 200 amp. capacity. Also relay tube, or tube and solenoid may be ordered separately.—*Durakool, Inc., Elkhart, Indiana.*

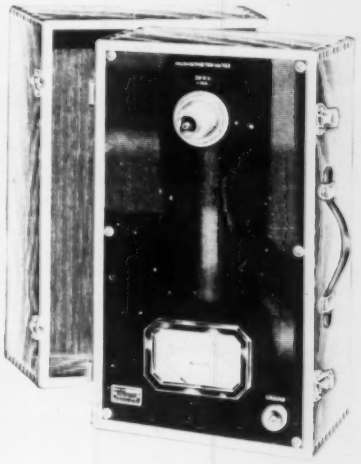


Consider the safety angle

IN MEASURING HIGH POTENTIALS!

Use the

SHALLCROSS
PORTABLE KILOVOLTMETER



You'll find this not only a practical and inexpensive instrument but one *with an unusually high safety factor as well.* A compact, relatively small unit that can be portable, or permanently installed.

Separate multipliers can be furnished for a wide variety of standard instruments used for measuring potentials up to 25,000 volts A.C. or D.C.

Not affected by humidity. Easily adapted for use as resistance standards, particularly those multipliers for use with low current instruments requiring high resistance.

SHALLCROSS "AKRA-OHM" RESISTORS

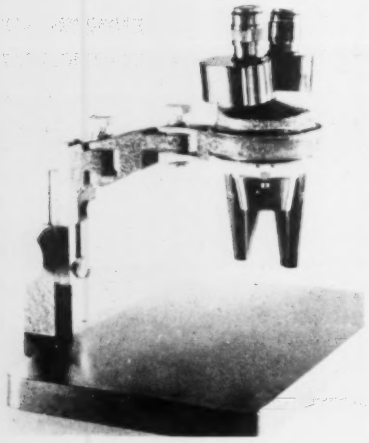
Type 110—are used in this box and there are none finer. Calibrated to an accuracy of 0.1 of 1%. Wound with specially insulated resistance wire on precision machined forms made of the finest grade of non-hygroscopic ceramic material available. Moisture proof. *They hold their calibration!*

Write for Kilovoltmeter Bulletin No. 700-H.P. and Resistor Bulletin No. 122-H-2

SHALLCROSS MFG. CO.
Instruments—Resistors—Switches
COLLINGDALE, PA.

Stereoscopic Microscopes

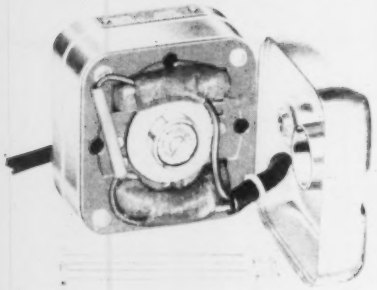
New series of stereoscopic microscopes is said to embody notable optical and mechanical improvements. Optical characteristics include "a vivid stereoscopic image that is



easier on the eyes, a great depth of focus, an exceptionally large object field and a high degree of resolution of fine detail giving critical sharpness to the image." Mechanical improvements facilitate focusing on large or small specimens, provide for quick changes in magnification. Objective lenses are held in a dust-proof revolving objective holder. New instruments are heavier and more rigid, are offered in four different mechanical arrangements to cover a wide range of uses. Magnifications range from 6.3 × to 144 ×. Seven different powers in paired objectives and four different powers in paired eyepieces provide a total of 28 different magnifications. Angle between axes of paired objectives is 12°. In prism boxes, each line of light is bent 2° toward center so that convergence at eyepieces is 8°. It is said that this dual-convergence, maker's exclusive feature—maintains stereoscopic effect yet makes it possible to work comfortably for long periods without eyestrain. *Spencer Lens Co., Buffalo, N. Y.*

Ball-bearing Motors

New ball-bearing and self-aligning sleeve-bearing shaded-pole motors are said to have high locked rotor and accelerating torque in combination with high electrical efficiency



and large output per unit weight. Alignment is accomplished by use of die-cast end frames with a spacer shell held in compression by means of through bolts. A recess in end frame is for spacer shell, a second recess positions and locates the stator. It is said that bearing alignment is maintained even though the motor receives rough handling. Ball-bearing motors will operate in any position and will withstand substantial end thrust. Self-aligning, semi-oil-less sleeve bearings are also available. Power output ranges from 3 to 15 watts. A.C. motors are of four-pole design with top speed 1800 r.p.m. *Russell Electric Co., 67 W. Huron St., Chicago, Ill.*

FOR ALL SCIENTIFIC USES

GALLET

GUINAND

and SECURITY

TIMERS

The Widest Selection of **TIMERS** and **CHRONOGRAPHS** Best Quality in every Price Range

FREE Catalog on request

JULES RACINE & CO.

20 WEST 47th ST., NEW YORK

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VACUUM GAUGES

(PIRANI TYPE)

Priced From $39.50

Circular on Request.

CONTINENTAL ELECTRIC CO.

GENEVA, ILLINOIS

Vacuum - - - Thermocouples

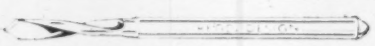
featuring

DEPENDABLE STABILITY
HIGHER OVERLOAD
FASTER RESPONSE

Our thermocouples will meet the most rigid requirements. Write your requirements to—

American Electrical Sales Co., Inc.

67 E. 8th ST. NEW YORK, N. Y.



SMALL DRILLS

from .0016 up to .1969 inch diameter, all sorts of small turned parts. Small wood screws in brass, steel, etc., turned from the bar.

BLACK GRINDING DISCS

H. C. M. ENGEL, Inc.

P. O. BOX 233, SIDNEY, NEW YORK

Short-wave Transmitter for Research

New "Synchrotone," embodying improvements over preceding models, is an adjustable r-f. transmitter suitable for the therapy effects discovered

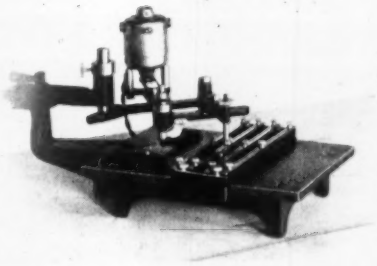
by Hall[illegible], but for laboratory investigations of effects of various frequencies and various electrics on every type of organic substance or norganic material. Frequency is continuously adjustable between 65 and 120 Mc., energy, up to 25 watts. Announcement emphasizes possibilities of research into athermal or low-temperature effects. New transmitter will not produce interference with radio communications or television, has been designed to eliminate danger from burns and sparks.—*Hall[illegible] Synchrotone, Inc., 527 Madison Ave., New York City.*

Automatic-reset Timer

New "RS Automatic-Reset Timer" is an industrial instrument for automatic timing of a variety of electrical circuits. It consists essentially of an enclosed snap-action

switch unit which is actuated by an operating arm driven in one direction by a small synchronous motor with an enclosed magnetically-operated gear clutch and spring. Setting means to starting position after time cycle has been completed. Time settings are adjusted by setting pointer to desired time on scale. Several time ranges are available. Contact has a capacity of 7½ amps. at 115 volts or 5 amps. at 230 volts. Instrument can be furnished for flush panel mounting or in a dust-proof die-cast case suited for BX or conduit wiring.—*The E. W. Cramer Co., Inc., Centerbrook, Conn.*

-MICO-
ENGRAVER



For lettering panels of steel, aluminum, brass, or bakelite, or for marking finished apparatus.

Attachments adapt it to small or large work on flat or curved surfaces.

Excellent engraving can be produced by an inexperienced operator.

Widely used for production as well as occasional engraving.

Samples of work and catalogues on request.

Price with Type—$113.50

Mico Instrument Co.
16 ARROW STREET
CAMBRIDGE, MASS.

IMPROVED "SPOTLIGHTS"

Rubicon MULTIPLE REFLECTION galvanometers have recently been much improved through redesign of optical system. The definition of the line-image is now so sharp that readings can be estimated to .1 of a millimeter division.

These sturdy self-contained galvanometers are available with sensitivities as high as 5×10^{-9} ampere and 1×10^{-6} volt per millimeter division.

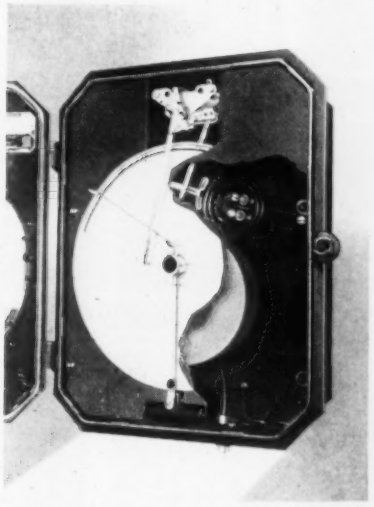
ASK FOR BULLETIN 329

RUBICON COMPANY
Electrical Instrument Makers
29 North 6th St. Philadelphia, Pa

Galvanometers, Electrometers, Potentiometers, Colorimeters, Wheatstone & Kelvin Bridges, Resistance Standards, Resistance Boxes, Coil Testers Clip-on Ammeters, etc.

Recording Thermometers

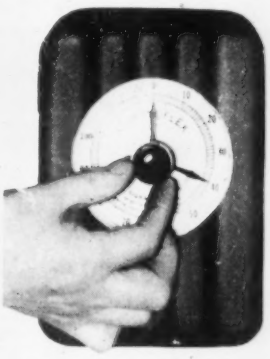
Companion recording instruments for redesigned "Fulscope" controllers (*Instruments*, April, 1940, page 99) are now recorders for temperature, humidity, pressure,



heat, rate of flow, liquid level, and receivers for pneumatic transmission systems. Cases of new recorders are drilled and tapped to receive "Fulscope" control mechanism should it be desirable to add it at a later date. New universal case is for face or flush mounting. Chart-changing time is cut in half by new mechanism that combines chart locking device and pen lifter. Aluminum chart plate provides rigid surface for pencil notations on chart. New recorders are available with 10" or 12" charts, and with one, two or three pens. Improved sublense permits more accurate calibration and assures precise location of replacement systems in field.—*Taylor Instrument Companies, Rochester, N. Y.*

Instantaneous-reset Timer

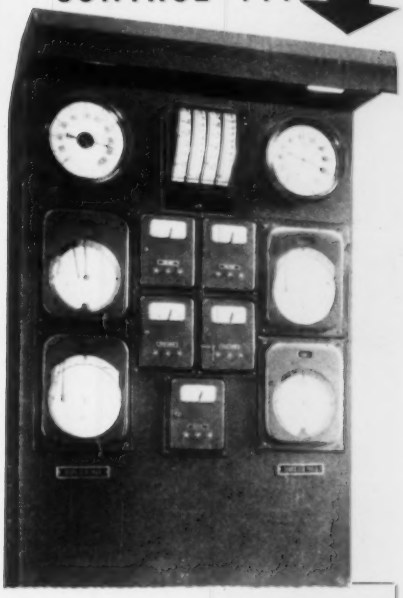
New "Chronotrex" is said to be a fully-automatic instantaneous reset timer designed for industrial applications. Its repeat-cycle switch for external control has "X"



silver alloy contacts obviating, in many applications, the use of contactors or relays. Synchronous motor is of slow-speed type, consumes 5 watts. 1" dial shows both finished and unfinished portions of the time cycle. Adjusting knob with time setting pointer is located directly in front. Solenoid controls a clutch having 2 disks with "rip saw teeth" to insure positive gripping action. Timer can be adjusted for clutch engagement when solenoid is energized or deenergized. Shock-absorbing device cushions blow of solenoid operation. Two standard models—one with a cycle range from 0 to 120 seconds, the other from 0 to 20 minutes. Special cycle ranges can be furnished. *Eagle Signal Corp., Moline, Ill.*

HERE'S Hays

CENTRALIZED COMBUSTION CONTROL . . .



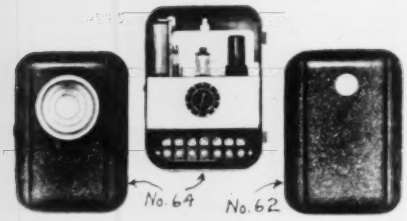
HAYS is the one truly CENTRALIZED control system—All of the control and measuring instruments are contained in one panel. Here is concentrated all information necessary for an intelligent understanding of what is going on inside the furnace, boiler and steam lines. And from this central panel the entire control system or any individual part of it may be operated manually.

Hays Centralized Combustion Control is offered through capable engineering organizations located in all principal cities of the U.S.A. and Canada. Correspondence is invited. Send for our 40-page catalog. Write to 925 Eighth Avenue, Michigan City, Indiana.

The HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

Photoelectric Control Units

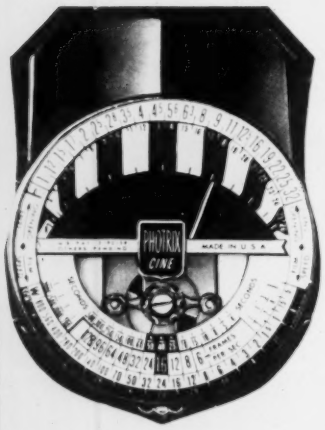
New "No. 60 Series" photoelectric controls are housed in 3" x 6½" x 4¼" enclosures having half-inch knockouts in bottom for power connections, and a fourth knock-



out on top to provision for wiring in an external photocell. Telephone type relays ordinarily provided permit a maximum isolated inductive load of 1 amps. a.c. at operation speeds up to ten per second; however a Microswitch to carry ½ amps. or another contacting device handling 15 amps. at 110 volts will fit same housing. In Model 60, the photocell is separately housed, making possible mounting control up to 5 ft. away. Model 61 employs a 2" collector lens to the photocell for applications demanding response from as little as 0.5 foot-candle with zero ambient illumination. Units utilize a commercially-available 625 amplifier tube. Photocell tubes used have life expectancies of upwards of 10,000 hours. Makers also announce "a complete line" of light sources designed to be used in conjunction with new line of photoelectric controls. *Uniod Corp., 43-37 33rd St., Long Island City, N. Y.*

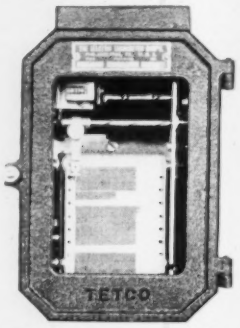
Exposure Meter

A new "Photrix Cine" photoelectric exposure meter is said to meet requirements of modern moving picture photography. Scale of operating speeds range 6 fr. sec. to 128 fr. sec. is movable and can be set accord-



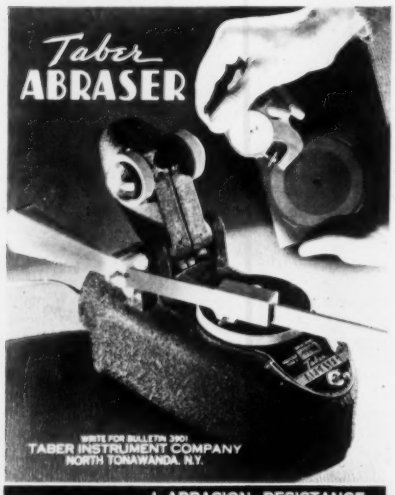
ing to shutter speed of the cine camera with which meter is being used. Pointer indicates F stops directly. Under all ordinary conditions, i. e., as long as same camera, same operating speed and same type of film is being used, no setting is required from one shot to the next. Bakelite casing forms a tapered light chamber in front of photocell, so that angular response does not drop off gradually towards sides but forms a sharply-defined light-acceptance angle of 50°. Sensitivity range covers all light conditions under which cine shots can be taken. F stop scale comprises 8 openings from F 1 to F 32. Emulsion speed scale covers range from 0.5 to 800 W and from 8 to 48 SCH. For use with still cameras, dial is provided with shutter speed scale. *Intercontinental Marketing Corp., 8 W. 40th St., New York City.*

TETCO
Speed Recorder



Creates a permanent time record on a waxed chart. Accurately records rate of production, time and duration of stops, total quantity produced.

The Electric Tachometer Corp.
1358 Spring Garden St., Philadelphia, Pa.



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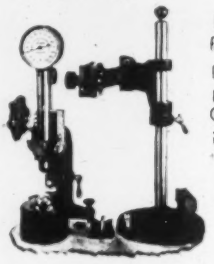
ABRASION RESISTANCE
PLASTICS • ORGANIC COATINGS
ELECTROPLATE • TEXTILES
SHEAR HARDNESS
PLASTICS • ORGANIC COATINGS

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 30 years.



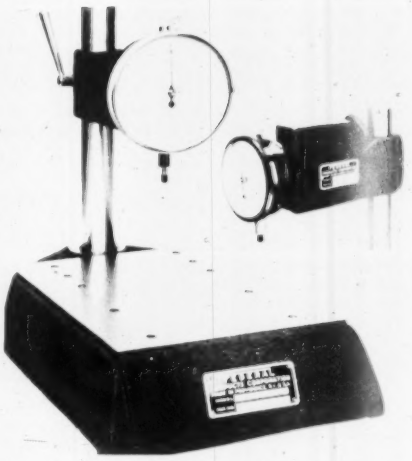
In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

Illustrated bulletins free.

The Shore Instrument & Mfg. Co., Inc.
9025 Van Wyck Avenue Jamaica, N.Y.

Re-designed Comparator

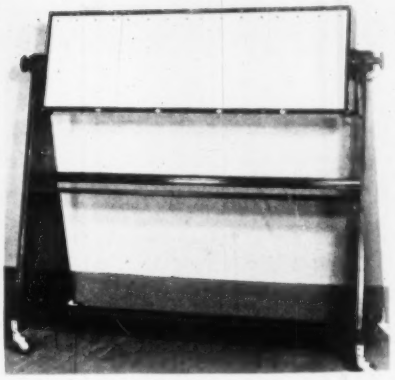
The new "Model NB-60" comparator has been entirely redesigned, is supported on three feet instead of four. Support column is heavier; regular supporting



bracket holds indicator by back instead of by stem. Holes are provided in base through which an angle attachment can be fitted for holding cylindrical work or to set work stop for work placed on the platen. Optional equipment is "AN-4" attachment which takes place of regular supporting bracket, provides a fine setting for indicator by means of a thumb screw located just in front of post. This bracket allows adjustment of 0.010" to 0.020". Regularly a 3½" size indicator is furnished, graduated in 0.0001". When the AN-4 attachment is used, a 2½" indicator is furnished, graduated in 0.0001". Other indicators can be substituted, if desired. Among uses of new instrument: setting and checking other gages to be used in production inspection; also used itself directly in production and inspection. *Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Radiographic Illuminators

Development of the fluorescent lamp has made possible the design of improved radiographic illuminators. One new model provides a 14" x 17" viewing surface illumi-



nated by two 18" 15-watt fluorescent lamps. An additional unit 17" x 56" in size, illustrated is designed to accommodate four standard films at one time. This unit utilizes ten fluorescent lamps, and like the smaller companion offers lower power consumption, less heat, and greater intensity without increased glare. Light distribution over the entire film area, which is of highest importance in examining exographs, is said to have been greatly improved. *General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.*

If your needs call for stable voltage at all times you can depend on SOLA CONSTANT VOLTAGE TRANSFORMERS to deliver for you, even though the incoming line voltage varies *as much as thirty percent*. Practical, economical, trouble-free, they can replace voltage regulating transformers or perform as auxiliaries to equipment now in use.

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GCV—22

SOLA

SOLA ELECTRIC CO. 2525 Clybourn Chicago, Illinois

Thermometers
Hygrometers
Psychrometers
Hydrometers

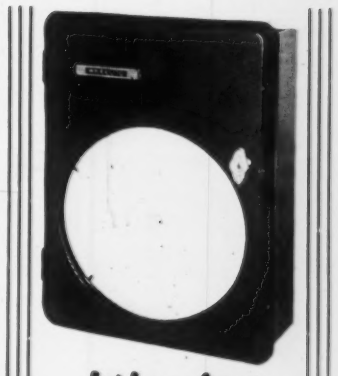
Several hundred types and varieties of instruments are described in new Catalog 110, but since ALL of them are produced in our own factory under our own experts' supervision, the best materials and high-grade workmanship characterize EACH of them.

Our customers find special satisfaction in the choice of FOUR different styles of thermometer glass: 1. White enamel back; 2. yellow enamel back; 3. Hespe; 4. red-reading mercury.

TWO WIDELY USEFUL NUMBERS

(Left) No. 169. For pressure-cooking processes, with two scales: 170-270 F. and 0-30 lbs. pressure. 9" scale length. (Right) No. 326. Max. & min. registering thermometer in 12" shelter type copper case. Approx. range minus 40 to 120° F.

Weksler Thermometer Corporation
535 PEARL STREET NEW YORK, N. Y.



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RECORDING
THERMO-TROL

Now the famous Wheelco Radio Principle* control system that has been making control history for the past few years, is combined with a highly efficient thermometer recording unit. This control and recording combination especially designed for exacting requirements. The entire unit is enclosed in a dust and fume-proof case and chart is clear view at all times.

Complete details on request.

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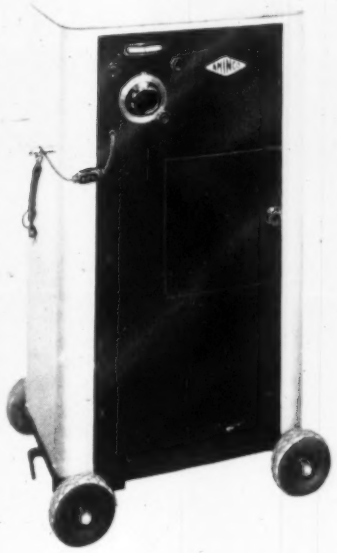
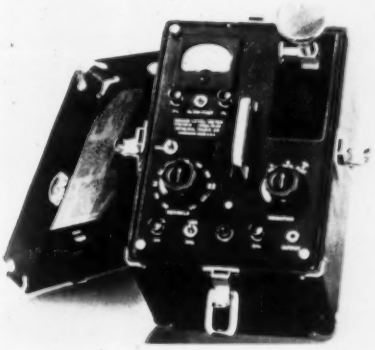
A new "Area Determinator" permits rapid measurement of the area of any flat object of any shape, color or texture that will fit into a circle 3.93" in diameter. Object may be opaque or translucent or transparent if temporarily coated with an opaque or translucent substance. Instrument is accurate within 3% of true area. Reproducibility, within 0.2%. A measurement can be made in 45 seconds. Measured area is read directly from a dial. Instrument operates direct from the house current supply. Dimensions 18" × 26" × 12" high. —*American Instrument Co., 8010 Georgia Ave., Silver Spring, Md.*



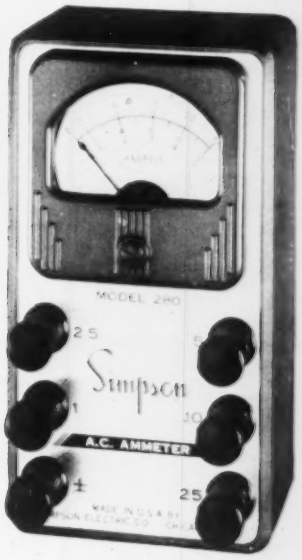
Sound-level Meter

A new "Type 759-B" Sound-Level Meter is an improved model of older "Type 758-A." It meets the standard specifications for sound-level meters as adopted by American Standards Association and various engineering societies. It is suitable for use in noise surveys, and for measuring the noise generated by machines and appliances. Features of new instrument are enhanced accuracy, rugged construction, convenience in operation, and portability. A two-speed indicator with selector switch is provided. In the "fast" position of switch, speed conforms to ASA specifications. In "slow" position, indicator is heavily damped and can be used for measuring average value of rapidly fluctuating sounds. New types of vacuum tubes and batteries give reliable operation and long life. Entire assembly is mounted in portable airplane-luggage type of case. Batteries are self-contained. Range is +24 to −140 db. Provision is made for connecting maker's "Type 760-A" Sound Analyzer for analyzing the noise spectrum. —*General Radio Co., Cambridge, Mass.*



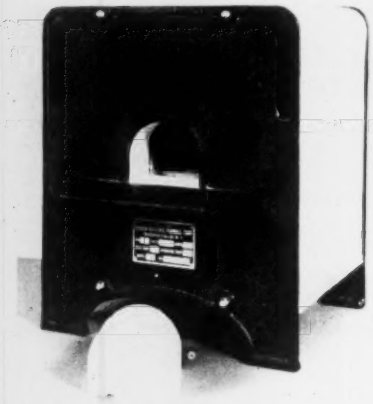
Five-range Pocket Ammeter

Announcement states that "for the first time a current transformer and an indicating instrument have been combined in a small a-c, multi-range ammeter that sells at a price almost unbelievably low." New "Micro-Tester Model 280" has five ranges, 1-2.5-5-10/25 amps.; is housed in a red Bakelite case with satin-finish steel front panel; measures 2¾" × 3¼" × 1¾", weighs 20 oz. Also announced is new line of "Micro-Testers," companion testing instruments, all same size, which can be combined in sets of three to measure current, voltage and resistance for almost every requirement." —*Simpson Electric Co., 5216 Kinzie St., Chicago, Ill.*



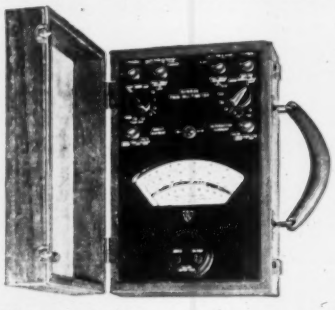
Laboratory Furnace

New "Type HL-3" laboratory furnace is heated by four Globar elements, attains 2,300 F. in one hour, requires 1500 watts to maintain maximum temperature. Muffle



dimensions 4½" wide, 2¾" high and 5" deep. Overall dimensions 17" x 13" x 12" deep. Control is by multiple-tap transformer. *Harper Electric Furnace Corp., Adams Road, Niagara Falls, N. Y.*

Rawson Twin Multimeter



29 ranges in less space than any near equivalent combination—size 12" x 8" x 6"

RANGE OF MEASUREMENTS

D.C. 1 microampere to 1 ampere
20 microvolts to 1000 volts
A.C. 10cps to 5000 cycles
2 milliamperes to 3 amperes
60 millivolts to 1000 volts

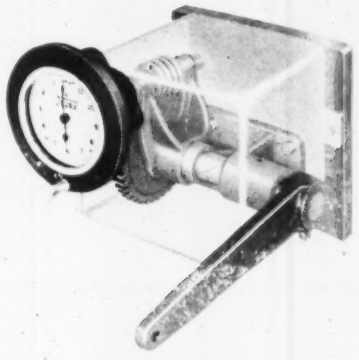
Special apparatus built to order

RAWSON ELECTRICAL INSTRUMENT COMPANY

110 POTTER ST. CAMBRIDGE, MASS.
Branch: 15 East 26th St., New York City
Representative: E. N. Webber
1313 W. Randolph St., Chicago, Ill.

Indicating Type Man[ual] Damper Operator

New self-contained model of [re]mote operator-indicator for dampers, [lou]vers, valves, etc., has mechanism enc[lo]sed as shown in illustration. It supplies [re]mote



type (*Instruments*, Oct., 1[9]40, page 2361) which operates damper by cable and quadrant. Indicating handwheel is [3]" in diameter; lever length is 8½"; weight [of] the *Tyler Engineering Corp., 2 Ellery St., Providence, R. I.*

INTERVAL TIMERS
PROCESS TIMERS
SIGNAL TIMERS
TIME SWITCHES
FLASHERS
Write
AUTOMATIC Electric Manufacturing Co.
Mankato, Minnesota

Electrolytic Capacitors

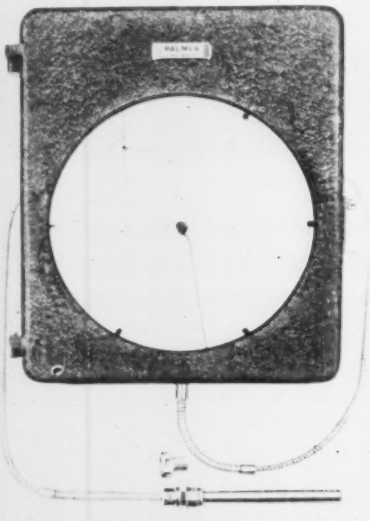
Said to meet higher voltage requirements, three new types of wet electrolytic capacitors are available in 4, 8 and 16 mfd. capacities, with a 600 volt d-c. surge rating.

In commercial with 550 and 500 volt ratings heretofore available. Can sizes are 1⅝" and 1¾" diam., and 2 7/16", 4 7/16" and 6 15/16" high. *Aerovox Corp., New Bedford, Mass.*

Volume Controls

New "Series 68" Volume Controls, with serrated shafts, permit replacements with

cut having to replace slip-on knobs. [Are] available in all required resistance values. *Clarostat Mfg. Co., Inc., 285[7] North St., Brooklyn, N. Y.*



Of Vital Importance

to all manufacturers is the knowledge that the correct temperature has been used in their various manufacturing processes and that the record is reliable.

Confidence in the Recording Thermometer is of utmost importance and those who use Palmer Thermometers know that every Palmer product is thoroughly dependable.

This NEW Palmer Recording Thermometer was not placed on the market until every detail had been perfected. It is the outstanding Recording Thermometer ever placed on the market for superior workmanship, sensitive registration of temperature and absolute accuracy.

Be certain your next Recording Thermometer is a PALMER!

(Write for Bulletin No. 1300)

THE PALMER COMPANY

Manufacturers: Industrial, Laboratory, Dial & Recording Thermometers

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Fabric Tester

"Model JF Textile Abraser" has specifically designed for determining quality of woven fabrics ranging from wool overcoating to sheer silk hosi-

Test is based on use of dual resilient wheels of standard composition which provides a unique wearing action, resulting from the two wheels alternately rubbing

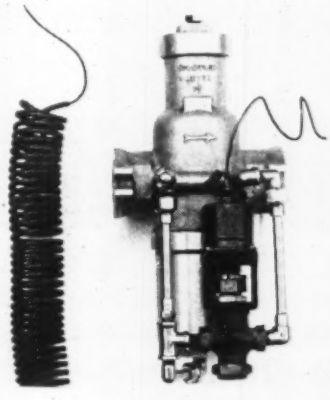
Automobile Upholstery

Napped Woolen Fabric

back and forth and at the same time crisscross their paths, approximating actual conditions of use. Constant rate of wear is obtained, insuring standardized, reproducible test readings.—*Taber Instrument Co., North Tonawanda, N. Y.* Also: *Alfred Suter, 200 Fifth Ave., New York City.*

Line-pressure-operated Pilot Valves

New temperature control system illustrated is latest addition to maker's line of controls built around a series of pilot-operated valves wherein the small pilot



valve commands the main valve by means of the pressure of the steam or other medium to be controlled. Small pilot valve may be actuated by a primary element responding to temperature, pressure, etc., or to a remote push button, time switch, etc. Control valves are furnished normally-open or normally-closed for on-and-off or throttling modes of control.—*Spunaler Mfg. Co., Inc., 548 E. Third St., Los Angeles, Calif.*

A COMPLETE instrument for your NOISE and VIBRATION TESTING

It's the RA-281 Recording Sound Frequency Analyzer

THE RA-281 is an adaptable instrument which meets the varied requirements of almost any noise or vibration testing problem. It serves as either a standard high-precision sound level meter or sound frequency analyzer; it is used with either the high stable Western Electric moving coil microphone or a new moving coil vibration pickup; it delivers the data on a large, readable indicating meter or an automatically recorded graphic record.

Calibration to Bell Telephone Laboratories standards assures precision.

The RA-281 is used by an impressive list of prominent industrial firms and government departments.

Write our Engineering Laboratories.

Electrical Research Products Inc.
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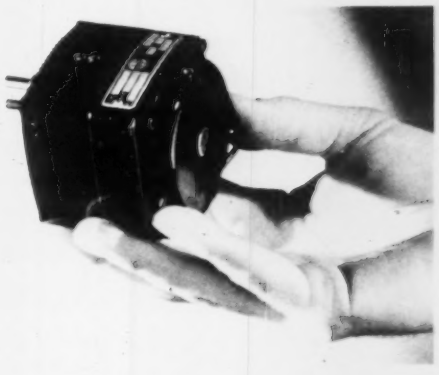
Engineering Laboratories: 76 Varick Street, New York

NEW

A midget capacitor motor with built-in speed reducer



Here's a new, small, but rugged built-in spur gear speed reducer motor, designed especially for continuous duty on instruments, timing mechanisms, and various control apparatus requiring exceptional reliability. Available in synchronous or non-synchronous capacitor models, in speeds from one to 300 rpm and torques from 1.3 to 120 inch-ounces. The motor develops from 1/750 to 1/2000 hp, depending upon the type of winding used.

1/1500 Hp Continuous Duty

The Type K motor is not a "toy" motor. It has no "permanent" magnet and no internal switches or brushes. It has distributed windings, a high starting torque, and can withstand stalling indefinitely. The unit is fully enclosed to provide complete protection.

Write for Bulletin

Bodine Electric Company
2254 W. Ohio St., Chicago
Name
Company Title
Address
City State

BODINE
FRACTIONAL H-P
MOTORS

THAT NEW TAYLOR PRE-ACT WOULD LICK THIS CONTROL TROUBLE, CHIEF. IT WOULDN'T COST MUCH, YOU KNOW
O.K., Pete; try it, before these sudden control upsets lick us. If this Pre-Act does the job, it's a few dollars mighty well spent!

WHAT WILL TAYLOR'S PRE-ACT DO FOR YOU?

Stop those costly, sudden control disturbances. Try this new Taylor Fulscope Control effect based on rate *of control-point deviation.*

PRE-ACT, Taylor's unique *new* control effect, is available with both *Adjustable Sensitivity* and *Automatic Reset* types of the great new Fulscope Controller. It reduces the over-peaking and oscillating which sudden control disturbances have been causing you on continuous processes that involve both long time lags and large capacities. The reason-why is apparent: Pre-Act brings about an immediate, relatively larger valve action based on *rate* of control-point deviation.

You may get Pre-Act as a standard, fully adjustable unit assembly which may be incorporated in the new Recording or Indicating Taylor Fulscope Controllers, either originally or when you desire to.

Ask the Taylor man for full details TODAY. Or write Taylor Instrument Companies, Rochester, N. Y. Plant also in Toronto, Canada. In Great Britain: Short & Mason, Ltd., London, England.

These Design Features of the New Taylor Fulscope Controllers Insure Consistently Better Performance

Automatic Reset (in the instrument case)—Fully and continuously adjustable over a much wider range, permitting the one correct adjustment your specific requirements demand. Simply, precisely constructed for even performance and easy maintenance.

Fully Pneumatic Sensitivity Reduction—Gives you consistent performance throughout the wider sensitivity range; minimizes the effects of instrument friction; and automatically compensates for fluctuations in air supply pressure. Pen movement and output pressure have a close linear relationship that insures better control on difficult applications. What's more, you may vary the controller sensitivity throughout the entire range with negligible changing in output pressure and without disturbance to the control point.

Universal Application—Same control mechanism for temperature, pressure, rate of flow, and liquid level in recording and indicating controllers. (Temperature and pressure recording controllers are available in double-duty form.)

Quick-Change Unit Construction—No soldered joints, no screws to drop. Cases drilled and tapped to accommodate most complete forms of control and to enable you to maintain easily and change from one form to another in the field.

Pre-Calibrated Actuating System—More easily interchangeable than ever.

Magnifying Adjustment Dials—Easier to read and adjust; calibrated in absolute units.

Easy Convertibility—From direct to reverse action.

Universal Case—Made of die-cast aluminum for face or flush mounting.

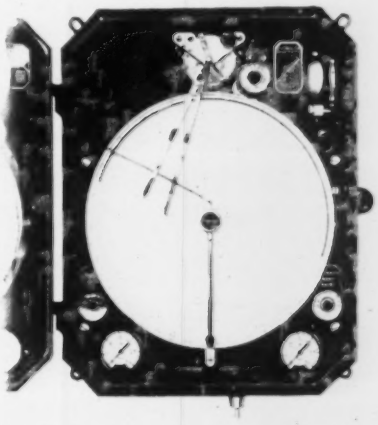
Electric Chart Clocks—Redesigned, with improved coils, oil-immersed gears and slower speed motors. Spring-driven clocks an alternate. Explosion-proof electric clocks also available.

Inbuilt Air Filters—Easy to clean, more efficient and accessible. They supplement large filter and drip well.

Quicker Chart Changing—Separate pen lifter and hub nut eliminated.

Accessibility—Dials and knobs instantly accessible without removing chart and chart plate.

Longer Life—All vital parts of 18-8 stainless steel. Neoprene gaskets throughout.



Only the New Taylor Fulscope Controller gives you these

5 FORMS OF CONTROL

Fixed High Sensitivity—for on-and-off control on applications with small time lags and large capacities, regardless of load changes.

Adjustable Sensitivity—for throttling control on applications with a wide range of time lags and capacities, where there are infrequent or minor load changes.

Adjustable Sensitivity with Automatic Reset (in same case)—for precision control on applications involving a wide range of time lags and capacities, with gradual, sustained load changes.

Adjustable Sensitivity with Pre-Act—for applications with a wide range of time lags and capacities, where there are sudden, momentary disturbances *without* sustained load changes.

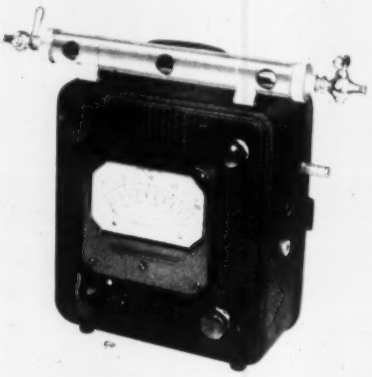
Adjustable Sensitivity with Automatic Reset and Pre-Act—for ultimate precision control on applications involving a wide range of time lags and capacities *with* sudden and sustained load changes. The Fulscope Controller, with all three effects, can be adapted to almost any of your control problems.

Taylor

Indicating | Recording • Controlling

TEMPERATURE, PRESSURE, FLOW *and* LEVEL INSTRUMENTS

CO_2 Analysis in a Few Seconds?



Yes, it requires only a few seconds to obtain a CO_2 analysis with the ENGELHARD FLUALYZER, and, any mechanic can make the checks accurately without special training. Tests prove that you will get results within .2 to .3 of 1% CO_2 against accurate Orsat checks. A list of users of this instrument will be sent upon request.

SEND FOR BULLETIN No. 700

CHARLES ENGELHARD, Inc.

90 Chestnut St., Newark, N. J.

Model 70-PO

Temperature Testing SIMPLIFIED by J-B-T MODEL 70-PO

● READ otherwise inaccessible temperatures in plant or laboratory . . . make sure recorders, pyrometers, and controllers operate on *correct* indication. Whatever the application, J-B-T Model 70-PO simplifies reading by eliminating the balancing operations of conventional potentiometer-pyrometers.*

Guaranteed accurate to ½ of 1% total scale deflection, this new type of instrument indicates quickly wherever a thermocouple tip can be inserted . . . at atmospheric ranges or up to 0-3000° F. Here is potentiometer independence of lead resistance with ease of reading a direct deflection instrument,* plus these features:

1. **No Standard Cell**—Just a flashlight cell, long-lived. Thus instrument withstands vibration and ambient temperature changes.
2. **Truly Portable**—Weighs less than 5½ pounds. Also available for wall mounting.
3. **Multiplicity of Thermocouples**—With special switch, any number of thermocouples are read without interruption for balancing.*
4. **Sensitive Galvanometer**—Sturdy double-pivoted movement protects accuracy of indicator by precise detection of null-point.
5. **Hand-drawn Scale**—Choice of mirror scale and knife-edge pointer, single or double-range, degrees or millivolts.

Write for details and quotations on Model 70-PO, also electric tachometers, laboratory galvanometers, pyrometers, and resistance thermometers.

J-B-T INSTRUMENTS, INC.

441-E Chapel St. New Haven, Conn.

*On scales of certain 6- and 12-inch circular and adjusted instrument reads with one further balancing. Larger scales require balancing for each reading, instead of two in conventional instruments.

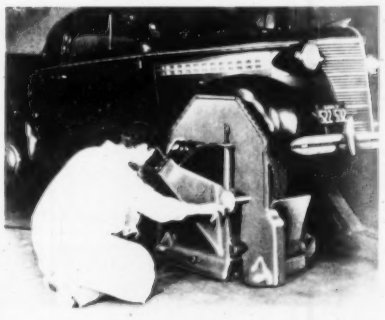
Height and Depth G[illegible]

New "Dead Height and Dept[illegible] facilitates reading with "micrometer accuracy in the most hard-to-get-at pl[illegible] It is furnished with rods which measu[illegible]

6". When used as a depth gage, or as an inside parallel surface gage, measuring rods are locked in position after measurement is taken; the depth obtained is then quickly read from a micrometer without need to add or subtract. For height measurements special height pin is inserted in place of measuring rods. With this height attachment, gage can be used for marking accurate Layout lines which are especially good for operations under magnification, since gage does not tear the metal. A three-point contact is maintained whether gage is used as a height or depth gage, or for measuring inside parallel surfaces. Other uses for checking dimensions of stampings also in place of a production gage for checking small quantities of parts. New gage is available in deluxe set, complete with the disk scriber and measuring rods for up to 6" capacity, in a hardwood case. *Continental Machines, Inc., 1501 Washington Ave., South, Minneapolis, Minn.*

X-ray Tire Inspector

New "X-ray Tire-o-scope" shows exactly where and why a puncture or blowout may occur. Without removing tire from car, operator may, by x-ray, look into tire to detect breaks, bruises, cord separations that are otherwise hidden, and [illegible] foreign material as nails, glass and stones imbedded in casing. Unit is designed for inspection of tires on all types of passenger cars (except large buses) and on some of the smaller trucks. Its x-ray output is such that accurate inspection may be made of tires up to and including an 8-ply "Wide side-wall tire. (White side-wall mixtures including zinc oxide is more nearly opaque to x-radiation than standard black.) *General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.*



Measuring Open-hearth Bath Temperatures

By L. O. SORDAHL and R. B. SOSMAN

Research Laboratory, United States Steel Corporation, Kearny, N. J.

NEED OF A METHOD FOR ROUTINE USE

FOR many years the steel industry has felt the need for an accurate method of measuring the temperature of liquid steel in the open-hearth furnace.

The specifications for this temperature measurement are severe. The instrument must be portable enough to be moved quickly out of the way to clear the floor for charging and similar work. It must be rugged enough to stand steel-mill conditions, in which dust and vibration are the principal risks. It must make an automatic record, independent of any personal equation. Preferably, it should not require highly experienced personnel to operate successfully. Finally, it must do a better job than is now being done by the melter's trained eye.

The last sounds easy until it is tried. An experienced open-hearth melter is able to make a fairly good estimate of the temperature of his metal without the aid of any pyrometer. He does it by observing the activity of the reaction between slag and metal, the brightness of the slag surface, the effect of the metal on an inserted steel rod, the brightness of the liquid metal when poured from a sampling spoon. He is helped by his blue glasses, which are not merely protective but act as a color pyrometer. Although these methods are all subjective, yielding no record in figures, there is no use in trying to replace them with an instrumental record that is good only to ± 25 or 50 F. We need to set our ambition on temperatures that are at least reproducible to ± 10 F. (6 C.) and if possible accurately measured within that range of tolerance. Furthermore, the pyrometer must be one that can be used without interfering too much with the melter's regular work, or consuming too much of his time. We shall then have something really usable in controlling the furnace and the quality of the steel.

The liquid metal is inaccessible to direct observation in the furnace because of its covering of liquid slag. It is true that its temperature can be read with an optical pyrometer while the metal is being tapped into the ladle and again while it is being poured from the ladle into the ingot molds. These readings are in themselves quite precise, especially the readings of pouring temperature, but they are subject to a large correction for the emissivity of the metallic surface: at an apparent temperature of 2700 F. this correction amounts to + 250 F., using the generally accepted emissivity of 0.4, yielding a true temperature of 2950 F. There is no objection to adding a large correction provided we are sure of it, but it is unlikely that emissivity is independent of composition, even though pure iron and iron containing several percent carbon appear to have the same emissivity. We know already that the emissivity is measurably increased by certain alloying elements such as manganese and chromium and it may, for all we know, be affected by the gases escaping from a flowing stream. Furthermore, the readings are obtained when the metal is already out of the furnace or the ladle, when little can be done to change or control the temperature.

A COMPARISON OF METHODS

In view of the importance of this subject to the open-hearth process, one of the authors (Sosman), with the aid of pyrometrists from several steel plants, conducted a ten-day comparison of methods for open-hearth bath temperature at the Pencoyd Works of the American Bridge Co. in 1936. The methods compared were:

1. Dissolving-tube method, using a platinum thermocouple encased in porcelain and graphite.
2. Test-spoon method.
3. Bath-equalization method of Larsen and Shenk.[1]
4. Rod-boil method.
5. Slag bubble method.
6. Slag surface method.
7. Collins-Oseland tube method.

Our conclusion from this series of comparisons was that the Collins-Oseland tube held the most promise of becoming a practical and dependable method for routine use, although quite reliable readings were also obtained with the test-spoon when the procedure was carefully standardized.

DESCRIPTION OF METHODS

1. *Dissolving-Tube Method.*

A platinrhodium-platinum thermocouple is enclosed in a small porcelain tube of 3/16" (5mm.) bore and 1/16" (1.5mm.) wall. This is about as small and thin a tube as can be handled, and its use in the steel bath is only rendered possible by encasing it (loosely) in a graphite tube (Acheson artificial electrode graphite) 1 3/4" outside diameter and 14" long, tapered for 4" at the closed end down to 1/2" diameter. The graphite tube with its enclosed porcelain tube and thermocouple is set in a water-cooled head, and the thermocouple wires are led out through a pipe inside one of the two water pipes. An essential detail is a packing of asbestos cord around the porcelain in the opening of the graphite sheath to prevent the rise of gases which would carry spurts of steel up into the water-cooled head after the graphite has begun to dissolve away.

The combination is inserted through a door of the furnace, with a sheet-metal shield protecting the operators. When immersed in the steel bath, the graphite quickly dissolves away below the slag level, leaving the porcelain in direct contact with the liquid metal and immersed therein to a depth of 6" to 8". Within the slag layer the graphite remains to protect the porcelain. Readings of the emf. of the couple are made with a semi-precision portable potentiometer and can be continued for several minutes before the porcelain begins to be attacked by dissolved FeO or to bend under the lifting force of the liquid. If withdrawn in time, the couple can be used repeatedly, but there is evidence that either CO or iron vapor penetrates the porcelain and gradually contaminates the couple. To secure an accuracy of 5 F. in measuring the metal bath temperature at the point of immersion, the couple should be used only once or twice. We found that inequalities in the metal bath itself far exceeded the range of accuracy of the thermocouple reading.

Since these experiments were made, the British Iron and Steel Institute's Sub-Committee on Liquid Steel Temperature[2] has used a similar thermocouple method, but with a vitreous silica protection tube and no graphite covering. The supporting tube was not water-cooled, but protected by a porous insulating refractory. The pyrometer was used principally in the acid open-hearth, in which the slag is highly siliceous and therefore not so corrosive to silica as is the basic open-hearth slag.

Our method with the thermocouple and water-cooled head gives dependable results, at least in a killed steel bath, and will be used again as a basis for further standardization of the tube method (described later) which is now in practical use.

In an active bath or in a ladle of rimming steel, in which there always is a vigorous evolution of gas around any inserted colder object, it is doubtful whether a true temperature can be obtained with an immersed tube. Heat is being absorbed or released at the point of measurement and therefore the couple temperature cannot exactly equal that of the mass of metal. This point was brought out in a recent dis-

[1] Presented before the Symposium on "Temperature, its Measurement and Control in Science and Industry," American Institute of Physics, New York City, Nov. 2, 1939.

[2] Iron and Steel Institute Special Report 7, (1939), pages 23–264, pls. 20–22. (Sec. VII, Pyrometry of Eighth Report on the Heterogeneity of Steel Ingots.) See also Temperature Symposium paper by Schofield & Grace.

cussion of bath pyrometry[2] and should receive further experimental study.

The thermocouple or dissolving-tube method as used at Pencoyd is too awkward and expensive for plant routine control and is, furthermore, dangerous because of the presence of enclosed water near liquid steel. (See Figs. 2 and 3.)

2. *Test-spoon Method.*

Metal is held in or poured from a slag-coated test-spoon, and the temperature of the dark liquid in the spoon is read with an optical pyrometer. A correction for an emissivity of 0.4 must be added to obtain true temperature.

Not all test-spoon readings are satisfactory. Only when the slag is thin enough to permit the dipping of a clean sample in a properly slagged spoon can the reading be taken. If the slag is lumpy or viscous the readings are unreliable. To obtain satisfactory readings, a routine of slagging, dipping, removing from furnace, and reading, must be adhered to with rhythmic precision, for the metal cools so rapidly that even half a second's departure is significant. With an experienced reader, however, it was surprising to see how consistent the results could be.

Satisfactory readings by this method could not be obtained with a disappearing-filament optical pyrometer. Only the type in which the brightness of the image of the object is varied to match a small spot of constant brightness could be successfully used, because of the necessity of finding the target quickly and matching it almost immediately.

Our readings by this method, though self-consistent, proved, when corrected for an emissivity of 0.4, to be 20 to 30° F. higher than the probable true temperature.

3. *Bath-Equalization Method.*

In the course of their development work on the photoelectric roof pyrometer, Larsen and Shenk tested the principle of letting the open-hearth furnace come to radiative equilibrium and then measuring its temperature automatically.

A photoelectric roof pyrometer was sighted on the inner surface of the roof through an opening in the back wall. Another pyrometer of the same type was sighted downward through a water-cooled opening in the roof upon the slag surface. The two pyrometer circuits were connected in opposition, with a relay also in circuit which would turn on the fuel as soon as the difference between the two pyrometers fell below a certain set minimum of 10 or 20° F.

The procedure in taking a bath temperature was to shut off the fuel and air supply, throw in the relay circuit, and wait. Within a period of 15 to 50 seconds the slag, if not too viscous, would presumably have attained the temperature of the large mass of metal beneath it, in which most of the heat in the furnace is stored; at the same time the roof and slag would be equalizing in temperature by radiation—a process which is rapid at this high temperature. When metal, slag, and roof become equal in temperature within the prescribed tolerance, the fuel and air are automatically turned on. Meanwhile, the recorder of the roof pyrometer has been recording the roof temperature, and its minimum, shown on the chart when the returning flame causes a sudden rise, is the equalized bath temperature.

The bath temperature obtained in this way is in the nature of an average surface temperature and, if the bath is not homogeneous, readings at individual points, such as are obtained with thermocouple or spoon, will differ from it. This is probably the reason why we found that the equalization method gave a terminal temperature (just before tapping) that appeared more nearly correct than any other method, yet was more erratic than the results by the tube method which has the effect of stirring the bath vertically within a restricted area.

During the heats, the equalization temperature was 20 to 30° F. above the probable true temperature. Its precision is high, about ± 5° F. When more than one equalization temperature was taken during the tapping period, the furnace temperature was found to be diminishing at such a rate that it lost 5 to 10° F. during the 4- to 6-minute tapping period.

[2] *Transactions American Institute of Mining & Metallurgical Engineers*, Vol. 120, 1936. Pages 207, 209, 216.

4. *Rod-Boil Method.*

A cold steel rod is inserted through the wicket into the bath while it is still active, and an optical pyrometer is sighted on the surface of the metal as it boils up through the slag. (The boiling is caused by the escape of carbon monoxide from solution as a result of the local chilling.) Readings are made during reversal of the furnace, when the flame is off. There is no correction for emissivity.

The few readings which it was possible to secure by this method were consistent with the equalization and the test-spoon methods.

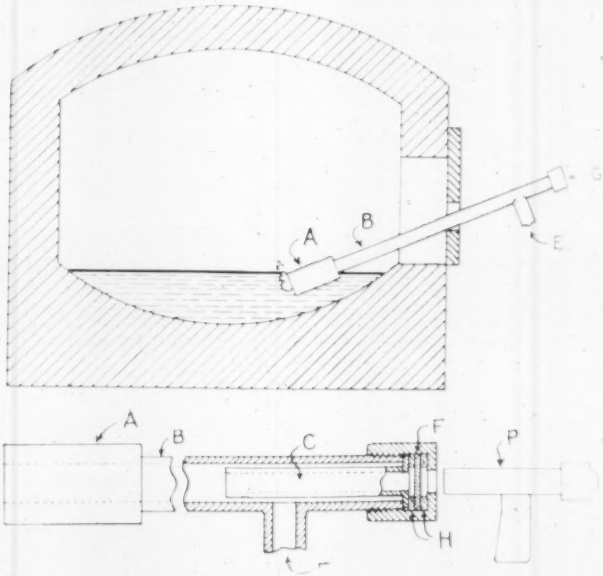


Fig. 1. Collins-Oseland tube as used at Pencoyd (drawings adapted from U. S. Patent 2,020,019).
A—Welded steel tip; B—Pipe; C—Inner pipe to protect window against moisture and dirt; E—Connection for introduction of air; F—Glass window; G—Air-tight cap, carrying window; H—Asbestos gaskets; P—Optical Pyrometer.

5. *Slag Bubble Method.*

An optical pyrometer reading is made, during reversal, on the interior of a gas bubble just as it bursts. The slag surrounding the bubble has just risen from the surface of the metal, presumably carrying the metal temperature with it; and in fact the bubbles can often be observed to be appreciably darker than the main body of slag. This indicator of metal temperature was suggested by Mr. Larsen.

The relatively small number of readings that we made by this method were, like the rod-boil temperature, consistent with the equalization and the spoon methods.

6. *Slag Surface Method.*

The temperature of the bath is inferred from a series of optical pyrometer readings during reversal, on the brighter areas of the slag as the bath is heated up towards the end of a heat. There is no emissivity correction.

The results by this method, as might be expected, could not be used as a basis for estimating the true temperature of the bath, even though they were useful in showing the general course of temperature increase as influenced by fuel input and other factors.

7. *Collins-Oseland Tube Method.*

The liquid steel is observed with an optical pyrometer through an open tube which is inserted into the liquid and is kept clear by a current of air. The method was developed by Carl Oseland and F. L. Collins in 1936 at the Gary Steel Works of the Carnegie-Illinois Steel Corporation.

As originally described,[3] and as used at Pencoyd in 1936, the Collins-Oseland tube consisted of a six-foot length of 2" steel pipe, closed at one end with a heavy glass window and provided at its other end with a steel tip having a central orifice ½" to ¾" in diameter. A side opening connected the

[3] F. L. Collins & C. Oseland; U. S. Patent 2,020,019; November 5, 1935.

...p a source of air pressure. See Fig. 1 for a diagram ...tube and Fig. 3 for a photograph of its appearance as ...the tests at Pencoyd.

...air pressure on, so that air is passing freely through ...e, the heavy tip end with the small orifice is inserted ...h a door wicket and submerged in the liquid iron or ...A reading is then taken with an optical pyrometer ...through the glass window on the bright spot out...by the orifice in the tip. Readings must be made quick...fore the pipe becomes hot enough to bend and before ...begins to melt into the bath.

...though the observer sees only a bright disk of light, the ...ng is actually being made on the inner surface of a ...or cavity in the liquid metal as seen through the ori...in the tip and maintained by the jet of air. This cavity ...a "black body" (perfect radiator) because one side of ...cold, and the optical pyrometer readings must therefore ...corrected. An emissivity of 0.61 had been roughly deter...at Gary, based on comparisons with optical pyrom...readings, taken during tapping and teeming of the steel, ...this proved to give temperatures that were too high.

IMPROVEMENT OF THE TUBE METHOD

The Collins-Oseland tube method as just described was found to yield consistent readings in the hands of an experienced observer. Its manual application in regular plant practice, however, is difficult from a mechanical standpoint. It requires the services of two men: one holds the pipe in position while the other takes readings with the optical pyrometer. The observer is under some nervous strain to obtain a reading quickly: he has to locate the small orifice, align it properly with the filament of the optical pyrometer, and make a blend in ten to fifteen seconds. Because of the air jet bubbling into the liquid bath, the tube is rarely steady and the optical pyrometer ordinarily used in plants is not sufficiently rapid to permit taking an accurate reading in the available time. Finally, the method is open to the serious objection that it is subjective: no autographic record can be obtained.

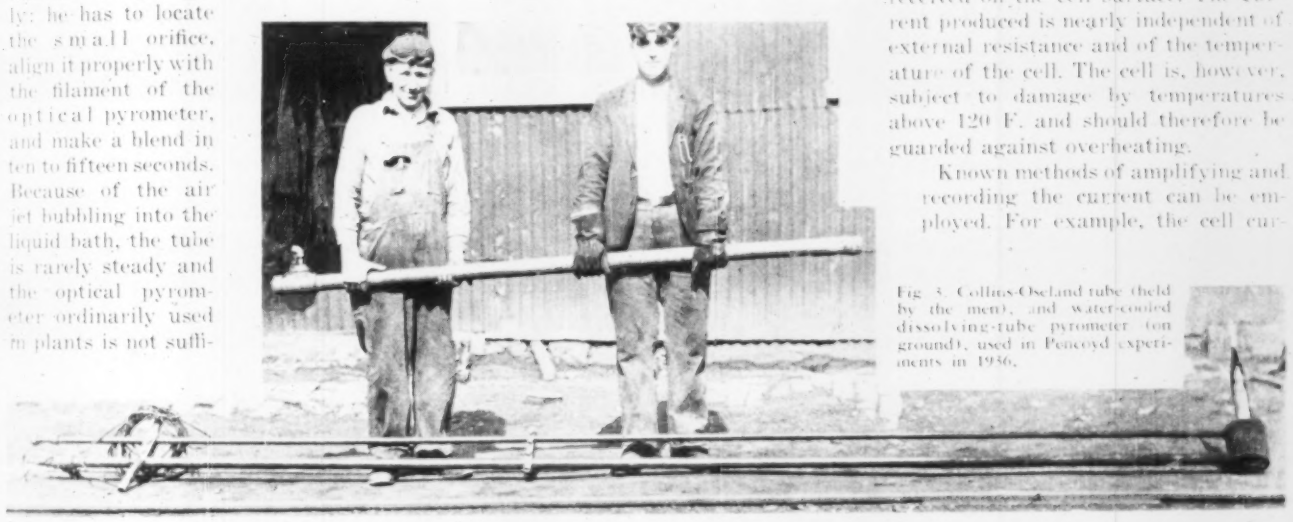


Fig. 3. Collins-Oseland tube (held by the men), and water-cooled dissolving-tube pyrometer (on ground), used in Pencoyd experiments in 1936.

We therefore undertook to make the method automatic by using a photoelectric recording pyrometer in place of the optical pyrometer, and now have a satisfactory combination that is in routine use.

The photoelectric automatically-recording part of the pyrometer was first developed several years ago by the Research Laboratory to solve the problem of high-speed recording of solid steel surface temperatures.[1] Its adaptation to the bath pyrometer was easy in principle because the temperatures are higher and the intensity of the available light at its source is much greater than in the application to solid steel surfaces. Balanced against this is the fact that the distances are greater (six to eight feet), the visible area small, and the total amount of light energy consequently minute.

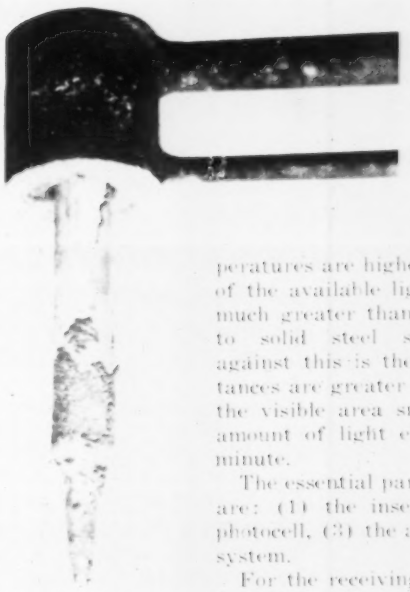


Fig. 2. Dissolving-tube pyrometer after a reading in the open-hearth bath, showing thin porcelain protection tube exposed by dissolution of the graphite in the steel, while protected by the graphite within the slag layer. (Photograph slightly retouched to show outline.)

The essential parts of the pyrometer are: (1) the inserted tube, (2) the photocell, (3) the automatic recording system.

For the receiving cell we have utilized the self-generative or blocking-layer type of photocell in the form known as the Photronic Cell. This cell delivers a current (of the order of hundreds of microamperes per lumen) proportional to the intensity of light received on the cell surface. The current produced is nearly independent of external resistance and of the temperature of the cell. The cell is, however, subject to damage by temperatures above 120° F. and should therefore be guarded against overheating.

Known methods of amplifying and recording the current can be employed. For example, the cell current can be sent through a fixed resistance and the potential drop across the resistance can be recorded by an automatic potentiometer. Or, the current can be amplified to operate a recording ammeter. In either case the recorder scale can be calibrated in terms of the bath temperature.

The Collins-Oseland tube itself, as used originally with an optical pyrometer, had to be modified to adapt it to the use of a Photronic cell as the sensitive element in automatic indicating and recording of liquid steel temperatures. An internal tube has been added to support a set of diaphragms arranged to prevent wall reflections. This inner tube gives added stiffness to the entire unit in maintaining the proper alignment of the optical parts within the necessary limits. See Fig. 4.[2] It is impossible to prevent some distortion or

[1] H. M. Larsen & W. E. Shenk. Temperature Measurement with Blocking-layer Photocells. Temperature Symposium, American Institute of Physics, New York, Nov. 2-4, 1939.
Also: R. B. Sosman. Pyrometry of Solids and Surfaces. American Society for Metals, Cleveland, Ohio, 1940, 100 pages.

From U. S. Patent 2,184,169, Dec. 19, 1939.

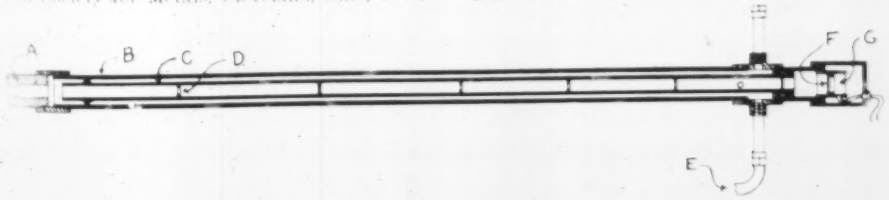


Fig. 4. Diagram of sighting-tube of photoelectric open-tube bath pyrometer. (Drawing adapted from U. S. Patent 2,184,169.)
A—Replaceable steel tip; B—Outer pipe; C—Inner pipe; D—Diaphragms; E—Hose connection for air supply; F—Protective glass; G—Photocell.

bending of the outer tube and to some extent of the inner tube by reason of irregular thermal expansion from non-uniform heating, but a reasonable amount of distortion is permissible since only the small orifice in the tip and the last diaphragm nearest the Photronic cell determine the incident cone of light under proper conditions of operation.

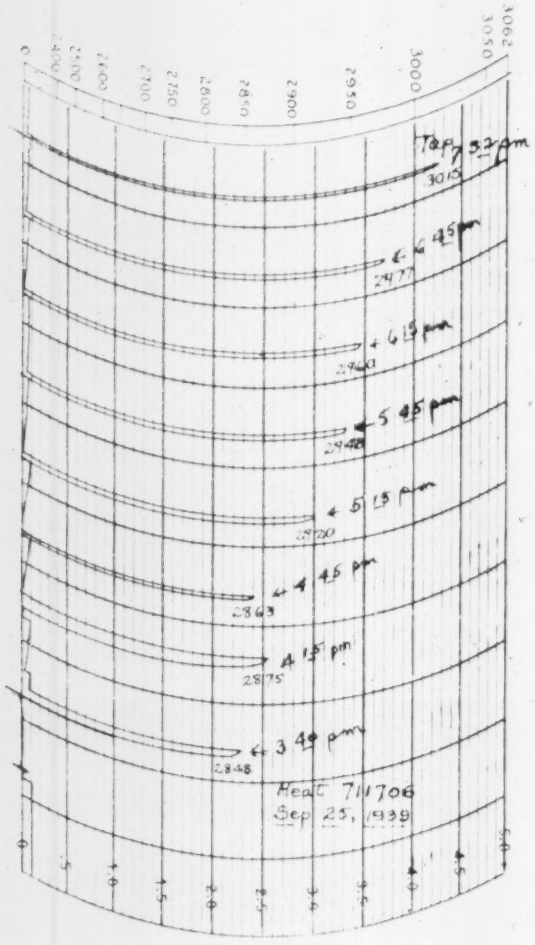


Fig. 5. Example of recorded open-hearth bath temperatures.

The Photronic cell, having a spectral sensitivity approximately corresponding to the visibility curve of the human eye, is well suited as a sensitive element in this application. Its response to radiant energy from a body below a dull red temperature is too minute to be detected with the arrangement used. This is of utmost importance since it eliminates errors due to radiation from the black hot interior walls of the tube; such radiation constitutes the major obstacle to the use of total-radiation receivers.

The output of electric current from the Photronic cell varies approximately as the twelfth power of the absolute temperature of the radiating source. This current-temperature relation is extremely useful for this application since it condenses the unimportant portion of the temperature scale and greatly expands the working-range portion. In other words, on a temperature scale covering the range from absolute zero to 3100 F., the last two hundred degrees from 2900 to 3100 F. extend over slightly more than one-half the entire width of the record.

Fig. 5 reproduces a series of bath temperature readings made during a basic open-hearth heat. When this record was made we were still using recorder charts with an evenly-divided milliampere scale, special charts having not yet been prepared; but the scale drawn across the top brings out the rapid expansion scale law whereby a temperature of 3000 F. can be read with a precision of 5 F. Readings can be reproduced within 10 F. It is therefore possible to control the temperature of a bath of given composition—provided that the temperature is uniform—to this precision. This does not mean that we know the actual temperature to any such degree of accuracy: absolute determinations must await further study and calibration.

The complete unit attains full-scale deflection in one second and a satisfactory temperature determination requires but five seconds. In regular steel plant service, from one to ten seconds constitutes standard practice in taking readings.

The all-steel tube in the hands of an experienced operator will last for more than a thousand readings and, barring an accident in handling, only the outer tube and tip need replacing. Readings at ten-minute intervals can be taken continuously with the same tube and if desired two or three readings can be taken in rapid succession but more time is then necessary for the tube to cool.

Comparisons have been made with compressed nitrogen in the tube instead of air on ordinary steel baths below 1% carbon during the last stages of the refining period. The nitrogen gave readings about 50 F. lower than air and a trend was noted showing a slight increase in temperature difference with increasing carbon content of the bath. In partial explanation of these effects it may be remarked that both air and nitrogen have a primary effect consisting of a cooling of the surface of the liquid metal. With air, this cooling would be balanced against the action of oxygen in reacting with the surface, brightening and heating it with the effect of making the apparent temperature higher.

Prior to furnace deoxidation or block, most open-hearth steels are fairly similar except for carbon content and the presence in some cases of the less easily oxidized alloying constituents nickel, molybdenum and copper; for this reason temperature readings during this period should be relatively comparable. However, the method has also been extensively used after furnace deoxidation, and after the addition of alloying constituents, on nearly every grade and type of alloy steel made in an open-hearth furnace, with consistent results and an undetectable effect from bath composition. The method is being used also in regular plant practice on electric furnaces, both in the furnace and in the ladle, on steels up to 14% manganese, and in the acid open hearth on steels up to 2% carbon, all with satisfactory results.

That there is no effect whatever from the bath composition is improbable; but this effect is so small (less than 10 F.) that we are unable to detect it with our present unsatisfactory methods of comparison. It seems quite possible that the rapidly and continuously renewing inner surface of the bubble or cavity is swept out of the field of view before any chemical reaction can manifest itself, and as a result we have an apparent emissivity which will vary but slightly with variations in the small amounts of alloying constituents. Consequently, the conditions are not comparable with those on the surface of a tapping or pouring stream.

The nature of the method has from the very beginning subjected it to the most critical and frequently skeptical scrutiny and although it is proving its worth in regular plant use by eleven units in eight different plants, we have planned to conduct, at the earliest possible moment, further tests and checks by means of an extensive thermocouple comparison under conditions of actual use.

ACKNOWLEDGMENTS.

We gratefully acknowledge the assistance of various persons in the Research Laboratory and in the plants of the United States Steel Corporation who have had a part in these experiments, particularly Mr. Lewis Rumford II who made the thermocouple measurements at Pencoyd; Messrs. Larsen and Shenk who furnished advice on photoelectric pyrometry; Messrs. R. H. Cantrell, H. J. Chapin, Carl Holland, J. W. Ready, Chester Siddall, H. B. Siddall, A. Thornton and J. D. Tyson, who took part in the Pencoyd comparisons; and Mr. J. W. Bain who has assisted in the development of the pyrometer in its present operating form.

Locating Buried Conductors

Method Employing Ground Tester as Signal Generator

By G. J. GROSS

Assistant Transmission Engineer, Pennsylvania Water & Power Co., Baltimore, Md.

Awarded Fifth Prize in First Annual Instrumentation Contest

TO extend the grounding system for increased lightning protection on an important electric power transmission line, there was a need to locate the existing wires and rods buried in the ground. This paper describes a device and method developed for the purpose, using a commercially available instrument and a home-made auxiliary coil. Other uses are suggested.

I—Need. Along a 230-kv. single-circuit steel tower transmission line there originally had been installed in 1931 four "counterpoise" or "crow-feet" ground wires, each 50 ft. long, buried about 18" in the earth, and terminating on a driven ground rod. One problem was to locate these rods and wire-ends so as to make extensions to the grounding scheme.

II—Former Method. When the job of counterpoise extension began in 1936, the ground rods were located by a "guess and dig" method. [Description deleted.—EDITOR]

III—Improved Method. To attack technically the problem of buried wire location, an attempt was made to utilize a large-diameter pickup coil and telephone receiver—a device employed years ago for the spotting of electric service line troubles that caused interference in communication circuits. A suitable coil was made by winding 175 turns of No. 23 enameled wire upon a wooden bicycle wheel rim approx. 25" in diameter. Wire ends were connected to binding posts and the rim was taped for wire protection. A nominal 75-ohm watch-case telephone receiver with head band was used as a detector.

It was the intent to employ the coil as a locator by the induction from leakage currents in the buried wire. It was found that this was not possible because there was a greater noise influence from current flowing in the transmission line overhead. Consequently, the idea of using the coil as a simple detector was abandoned.

An important phase of lightning protection on transmission lines is knowledge of resistance to ground of the footings of a supporting structure and also auxiliary grounding. For such resistance testing we have used a Megger Ground Tester which is a portable instrument containing a d-c. generator, reversing commutators and a direct-reading ohmmeter. (The commutator reverses the test current so as to avoid errors from stray earth currents and polarization of electrodes.)

It was discovered that test current from the Megger Ground Tester produced a distinctive signal in the pickup coil, and experiments were conducted to improve the correlated use of the combination, utilizing the Megger as a signal generator. As developed after extensive experience in the field the practice now employed is as follows:

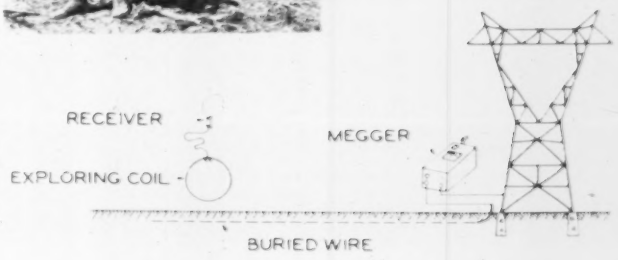
A buried ground wire, of which the length or location is desired, is disconnected from the tower. The C_1 and C_2 terminals of the Megger Ground Tester are connected to tower and wire. The potential coil of the Megger is disconnected by opening the link between P_1 and C_1 thus making the Megger ohmmeter element inoperative. The generator of the Megger is turned slowly by hand by one man, thereby putting a signal current on the buried wire. Another man, using the pickup coil and receiver, starts at the tower to follow the course of the wire. This he does by swinging the coil from side to side, changing the axis of swinging transversly to obtain the maximum signal. Progressing away from the tower, the signal gradually diminishes because signal current leaks off to earth. When there is a distinctive dropping off in the signal there is a wire discontinuity, so the coil is moved back and forth along its own plane to better observe the change. If buried wires are long or the ground resistance low, the signal current becomes low and may be compensated in either or both of two ways:

(1) Turning the Megger at higher speed produces more signal current at a higher frequency, increasing the audibility.

(2) Changing the Megger scale range to its lowest range, such as divide by 100 or by 1000, increases the audibility for two reasons. First, the range switch shunts the ohmmeter current coil and its resistance, thereby increasing the current delivered by the generator in the Megger. Secondly, as learned by cathode-ray oscilloscope analysis, the wave-shape of the signal voltage changes from a flat-top unipotential wave reversed by the commutator to a wave where the wave top or "half cycle" contains a number of oscillations, probably commutator ripples. These help to increase the signal.

(Left) Showing the "Megger Ground Tester" and the bicycle-wheel-rim exploring coil in actual use.

(Below) Electrical connections for using the "Megger Ground Tester" as a signal generator in locating buried conductors.



IV—Summary. Using the Megger Ground Tester as a signal generator, and with a pickup coil and telephone receiver as a detector, the following advantages are claimed for positive and accurate location of buried wires:

(1) The Megger has already been taken to the field for determination of ground resistance or circuit continuity so that no auxiliary signal source of current is necessary.

(2) The Megger contains no batteries that require service or replacement, hence is always ready for use.

(3) The pickup coil is sturdy and can withstand field abuse.

(4) The method is simple. No trained personnel is required. Mechanics, linemen and technicians alike are eager to learn and they become adept after a single instruction.

(5) The method saves time and labor in the location of: (*a*) individual wires in an electrical ground network, (*b*) driven ground rods, (*c*) buried water and gas pipes and metallic ducts, (*d*) buried electric service and telephone wires with non-metallic sheaths.

(6) The method can be used also to locate faults such as open circuits in ground wires and open circuits and low-resistance grounds on buried insulated conductors.

Locating Buried Cables and Pipes

By H. C. MARCROFT

Test Engineer, Pennsylvania Water & Power Co., Holtwood, Pa.

Awarded Honorable Mention in First Annual Instrumentation Contest

FOR locating cables, pipe-lines, conduits or other metallic conductors buried in the ground or in concrete floors and walls without having to dig, the apparatus herein described has proved of value many times from the standpoint of safety and in the saving of time and money. An official permanent order has been issued to all work crews of the company with which the writer is associated, to use this Detector in all places where cables, conduits or pipes are suspected, before doing any drilling or digging.

The apparatus comprises a magnetic pick-up coil on a U-shaped core, a vacuum tube amplifier (battery operated), and an indicating instrument in the plate circuit of the detector tube. This is a Westinghouse Style 423253 microammeter, full-scale deflection 100 ma. A later type with a full-scale deflection of 150 ma. is sometimes used. It has a resistance of only 3 or 4 ohms.

Fig. 1.

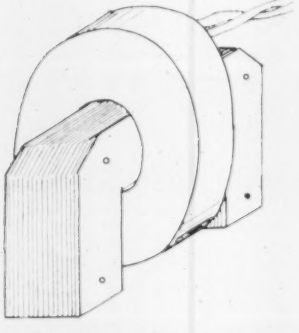


Fig. 2. Exploring Coil

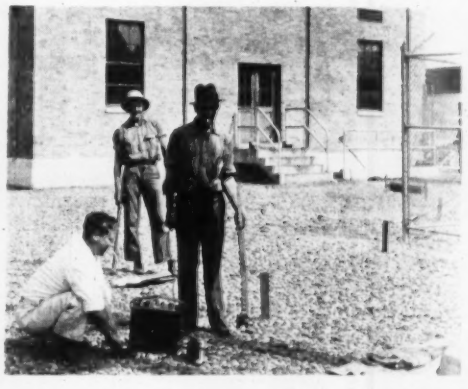


Fig. 3.

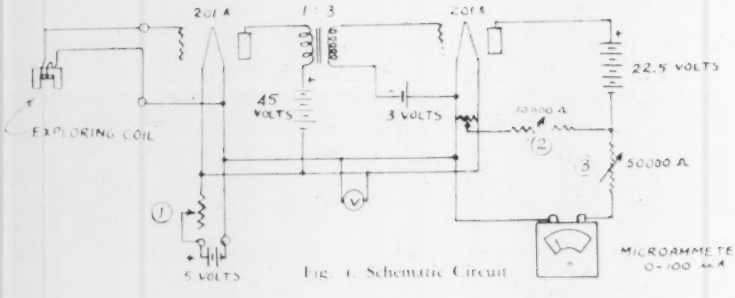


Fig. 4. Schematic Circuit

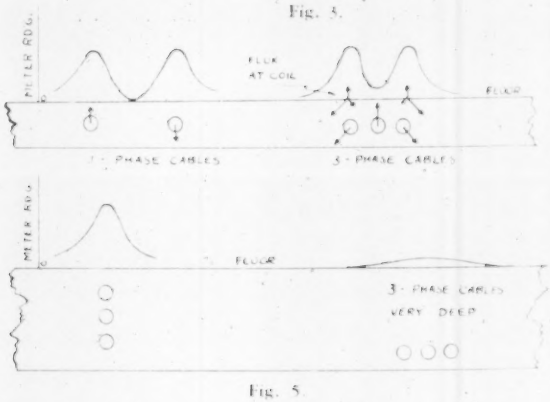


Fig. 5.

In Fig. 1 the microammeter is at the left, the amplifier in the center, and the pick-up coil at the right (attached to a handle for convenience).

Fig. 3 shows the Detector in use in an outdoor substation yard. The conduits are about 8 feet underground. A line of stakes can be seen marking their location.

The pick-up coil was made by taking a 1200-turn coil from an old watthour meter and placing it on a small laminated U-shaped core taken from a contactor. It measures less than 4" max. dimension. It is sufficiently sensitive when used with the amplifier to detect 60-cycle currents of 2 or 3 amps. at a distance of one foot.

The amplifier circuit is shown in Fig. 4. The tubes are both type 201-A. The first is used as an amplifier; the second as a biased detector. The plate and bias batteries are the small 22.5-volt units commonly used for portable work. Four of these are carried in the amplifier case. The filament power is supplied by four No. 6 dry cells.

To operate the Detector, the filaments are turned on by means of knob 1 and the correct voltage on the filaments is observed on the small voltmeter on the front of the amplifier. Knob 2 is adjusted to a value of resistance which makes the plate meter read zero. This adjustment is made with the pick-up coil away from any magnetic flux.

The pick-up coil is now used to explore the areas desired. By means of knob 3, sensitivity is controlled to suit the strength of field in which the pick-up coil is used. The coil is energized only by magnetic fields and is, therefore, a current-detecting device; the voltage of the circuit being worked on is of no concern. Both the location and direction of a hidden conductor can be learned since the pick-up coil will embrace the field when straddling the conductor and give a maximum indication, while a 90° rotation of the coil will give a zero indication.

The slightest deviation from position is easily detected, which is of great importance in laying out 3-phase cable lines because of the phase relation of the three fluxes. Several of the more common situations are shown in Fig. 5. Arrows showing phase relation are drawn for a clear understanding of the action of the pick-up coil in passing over various configurations. The meter indications are drawn on the vertical scale above the floor level.

Where the Detector is used at depths of several feet or more, or for the location of interconnected piping where it is impossible to isolate single sections, it is desirable to have a loading transformer for obtaining currents of several hundred amperes at low voltage. Such a transformer can be made from a discarded 5-kva. distribution transformer where the low-voltage winding is in good condition by stripping the high-voltage winding. The test cable is looped through the core several times to give the desired current for the Detector.

D-c. cables can usually be located with the Detector if they carry current generated by a d-c. generator. This is made possible by the commutator ripple. The ripple effect

...but its frequency is rather high, which increases the ...sitivity of the pick-up coil of the Detector.

...Detector has a big advantage in being able to detect ...nal commercial a-c. circuits directly without addi... apparatus except in cases where the circuits are ...d in iron conduits. Even then, the conduit frequently ...s enough ground current to operate the Detector. In ...where it is necessary, current may be put through ...nduits and the locations found just as easily as for ...ielded circuits. Oil and water pipe lines are detected easily by putting current through them. Wires in flexible metallic conduit or BX cable can be detected by putting current through the wires; sufficient leakage flux is present to operate the Detector where the cables are 8 feet underground, with only 50 amps. in the cable. Iron conduits have been located 13 feet underground with no difficulty.

This Detector has proved to be of such high value on so many occasions that it is difficult to think of trying to do any work around hidden conductors or pipe lines without calling upon its services.

A Buried Conductor Detector

By KENNETH J. GRANBOIS

Safe Harbor Water Power Corp., Conestoga, Pa.

Awarded Honorable Mention in First Annual Instrumentation Contest

WHEN cable conduits are placed in concrete it is not always practical to follow the precise location shown on drawings; but when chipping or drilling is to be done near these conduits it is necessary to know their exact locations in order not to damage them—not to mention the hazard of striking a high-voltage cable.

The exact location of any buried conductor can be located by energizing it with single-phase 60-cycle current and locating the resulting magnetic field with an exploring coil. The exploring coil is connected to a contact type rectifier, and the induced current is rectified and indicated by a direct current microammeter. The three parts of the apparatus are shown in Fig. 1. Part No. 1 is an ordinary telephone induction coil with the primary and secondary connected in series, the start of the primary is connected to the finish of the secondary so that their ampere turns are cumulative. Part

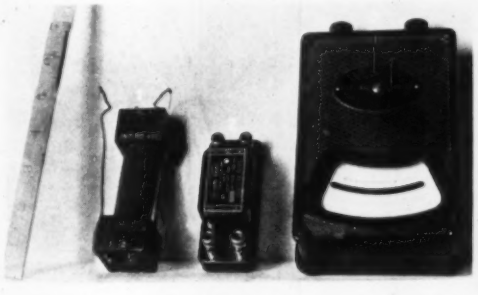


Fig. 1.

Fig. 2.

No. 2 is a General Radio copper-copper oxide rectifier. Part No. 3, the indicating instrument, is a Weston Type 440 microammeter, 150 ma. full scale, 3.6 ohms internal resistance. The instrument need not necessarily be a microammeter. A sensitive portable galvanometer would be better if extremely weak fields were being explored. Fig. 2 shows the coil and rectifier assembled on a convenient handle, ready for locating cable buried in a concrete floor.

If the cable to be located is a multi-conductor cable, only one conductor is energized. The return path for the current from the other end of the conductor is made by running another conductor over another location so that the magnetic field of the return conductor will not cancel or interfere with the field of the conductor being located. When the center of the exploring coil is over the cable and its axis is at right angle to the cable, the indicator reading is maximal; when the exploring coil is turned 90° the instrument reads zero. The amount of current applied to the cable being located depends on its depth, the size of the conductor and the source available.

Fig. 3 shows the variation of indicated current with distance between the exploring coil and the buried cable for different values of 60-cycle current applied to the cable, the coil axis being at right angle to the cable and the coil and cable being separated by air. No attempt is being made to calibrate the instrument and predict how far from the surface a conductor is located. The curves only illustrate the limitations of the device. If the conductor is more than 24"

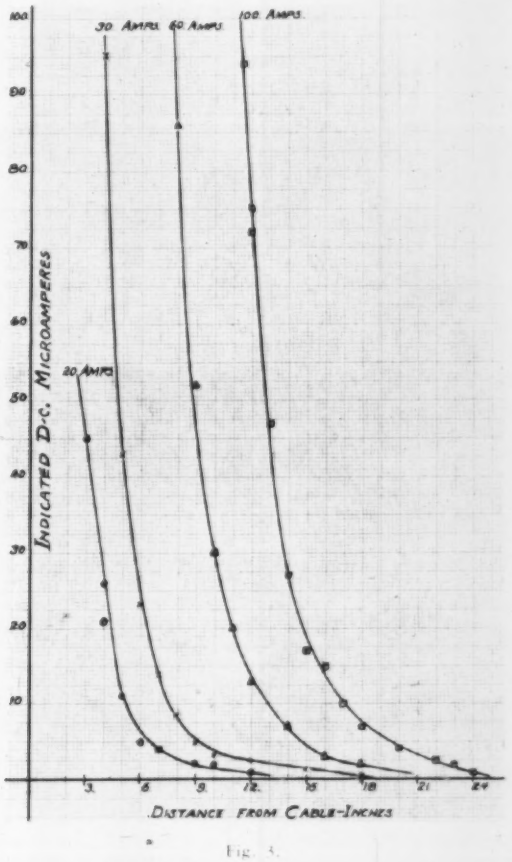


Fig. 3.

from the surface, 100 amps. or more will be required to locate it; if it is within 8" of the surface only 20 amps. will be required. A limitation of this method is interfering flux from nearby energized conductors, such as an isolated phase of a bus or a ground bus.

The exact locations of buried pipes as well as cables have been determined with this device by energizing them with several hundred amperes from a high current pipe-thawing transformer. The device is rugged and easy to operate. Any operating or maintenance man can use it with confidence.

Physical Processes Which Occur at the Point Where a Hardness Test is Made

Concluded from March Issue

By S. R. WILLIAMS
Professor of Physics, Amherst College

"CREEP" AND HARDNESS

Continued

To throw further light on this point the following experiment was performed. It takes its origin in an amazing discovery made by Osborne Reynolds[10] many years ago, which he called the phenomenon of dilatancy. It may be explained simply by saying that if spheres (granulates) are arranged in normal piling (see Fig. 24, Apr. 1937 instalment) the intergranular space will be a minimum. Disturb this condition and the space between the spheres or granules will be increased. Everyone has noted this effect when walking on a sandy beach just after a wave has retreated. The grains of the sand have been left in a condition of almost normal piling and the water still fills the interstices between them. If the wet sand is disturbed by the foot the intergranular space is increased and immediately the surface of the

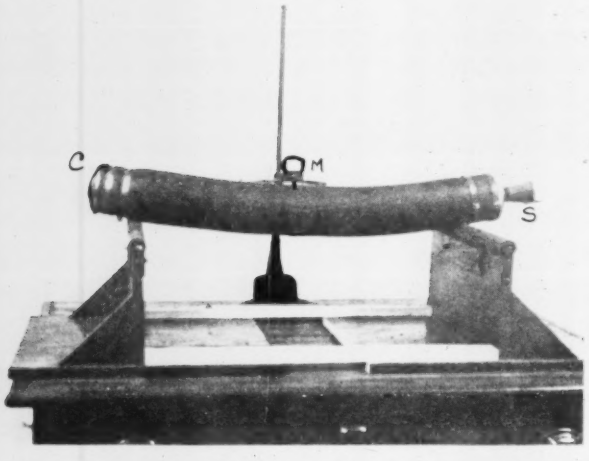


Fig. 249. A rubber tube is filled with closely packed sand whose interstices are again filled with water. When the stopper *S* is closed with no air in the tube, the latter becomes quasi-rigid.

sand loses its surface wetness because the water has been pushed by atmospheric pressure into the increased intergranular space within the sand. Osborne Reynolds showed that if a rubber balloon is filled with sand and all interstices are filled with water so that no air remains in the balloon, then the balloon with its sand and water take on peculiar properties. By removing all air and shaking the balloon into a pancake shape and then closing off the neck of the balloon, the rubber pancake became quasi rigid. The shaking down of the sand into a lozenge shaped piece put the sand into normal piling. On closing the rubber bag tightly, trying to change its shape increased the intergranular space and atmospheric pressure forced the rubber envelope rigidly against the sand, making the whole system of balloon, sand and water a rigid body.

[10] Osborne Reynolds: On an Inversion of Ideas as to the Structure of the Universe, Cambridge Press, 1903, Pages 1-44.

Following this idea of Reynolds a piece of straight inner tubing of an automobile tire, of 10 cm. diameter, was cut into a length of 75 cm. This tube was sealed off at one end by a metal cap *C*, Fig. 249, and in the other end a similar metal cap was inserted into which the screw cap *S* of a hot-water bottle had been soldered. This screw cap made it possible to fill the mouth of the opening of the tube with water and thus eliminate all air when the plug was screwed into the opening.

When the tube, filled with sand and water, was finally sealed off it became quasi-rigid and could be laid on two roller supports as shown in Fig. 249, quite analogous to the experiment shown in Fig. 244 with the square rod of marble laid on two knife edges in which the latter corresponds to the rollers under the tube of sand and water. Due to its own weight the tube has strains set up within the sand and water, which release by slippage at the grain boundaries. The tube with sand and water shows also the creep effect like marble but it goes much faster. This is shown in Fig. 250. The size of the sand used in

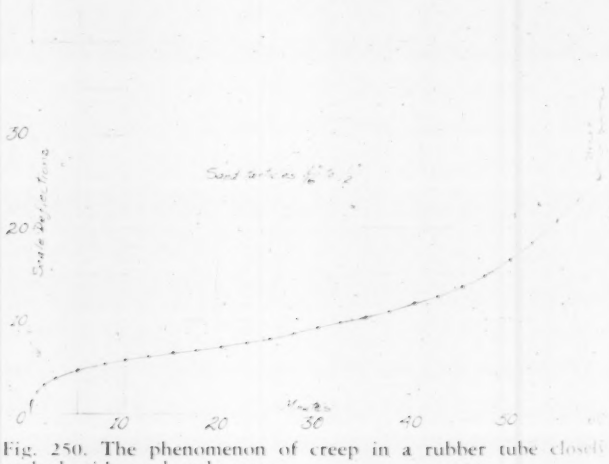


Fig. 250. The phenomenon of creep in a rubber tube closely packed with sand and water.

this experiment was such as would pass a screen of 12 mesh but would not pass one of 16 mesh. The creep was measured by setting a tripod mirror *M*, Fig. 249, with its two rear legs on a ring stand and the front one resting on the rubber tube itself. As the center of the tube sank a spot of light, reflected from the mirror *M*, moved along a scale. The curve in Fig. 250 was obtained in this way. Much more work should be done on this phase of the work, such as effect of grain size and kindred ideas. Fig. 251 is a photographic reproduction of the movement of the spot of light. This shows again that the process of creep goes forward by steps in a granular structure and one could in a fashion imagine these as cyclic.

Similar experiments are under way with glass. We have all seen glass tubing laid on two supports in the stock room and observed that in a year or so the tubing has crept into a permanently curved bow.

particular interest will be the creep effects to be in the plastics. Are they granular? If slippage oc a solid solution it would be over atomic or mole granules and therefore the steps, if any, would be all to observe by ordinary methods.

other factor plays an important rôle in hardness particularly for superficial hardness testing, and the influence of fine cracks in the surface, cracks arise from cold rolling, from heat treatment and enlargement of initial cracks by rusting, all of tend to weaken the surface tension of the solid. effect of surface tension or the lack of it was re- seen in a rotating, circular disk of a phonograph the author possessed. A hole had been drilled through the center of the disk, which was then mounted a mandrel in a lathe to trim off the upper surface so it would be at right angles to the axis of rotation. removing the surface and releasing the strains by weakening the surface tension, the disk curled downward it looked like a trench helmet.

Now if this surface layer in any kind of a material weakened, the hardness numbers will not be the same for the uniform undisturbed surface. A weakening in the surface of steel by fine cracks in the rolling and

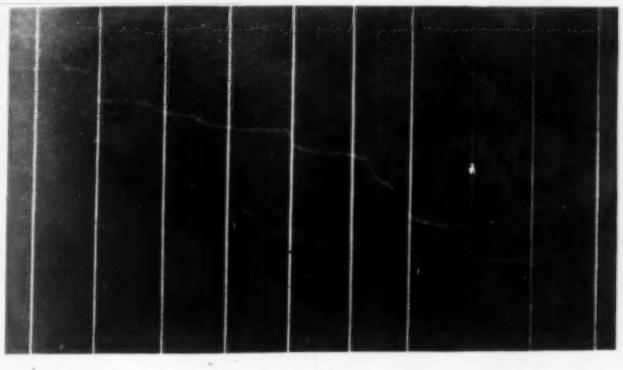


Fig. 251. Photographic record of the creep in a tube closely packed with sand and water.

tempering of the mainsprings of watches was vividly brought out by a study of the breakage of watch springs which was found to be seasonal.[1]

There are certain trade beliefs or notions which prevail widely among those engaged in those trades or professions. Among jewelers, for instance, it is a common belief that immediately after a thunder shower more mainsprings must be replaced than at any other time, that thunder showers are a cause for an increased breakage of mainsprings and that the primary cause is either electrical or magnetic because of the electrical discharges in the lightning flash.

In order to study this point experimentally, a watch mainspring was cut into strips about 5 cm. long. Nos. 1, 3, 5, etc. were put in one pile and Nos. 2, 4, 6, etc. were placed in another. One set was a check set for the other. These strips were then put under a strain by bending them into a U shaped form and thrusting the two ends into a round hole drilled in a strip of metal as shown in Fig. 252.

Under this condition of strain twenty or more strips of the watch spring were subjected to intense magnetic and electric fields. No breakage occurred. What other breakage? Evidently moisture, and if this moisture is due to the humidity at times of thunder showers, then the breakage must be seasonal. Accordingly the record

[1] S. R. Williams, A Seasonal Breakage of Mainsprings in Watches, *School Science and Mathematics*, Vol. 21, 1921, pages 737-743.

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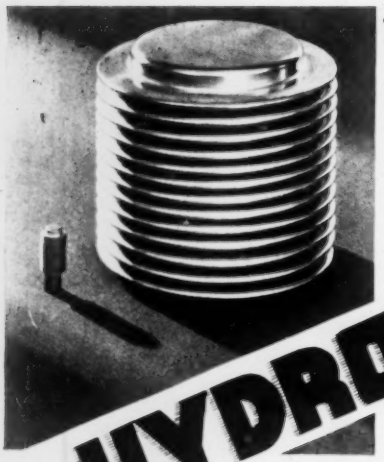

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books of two jewelers in two different towns of northern Ohio were consulted. If one takes watch spring replacement as going hand in hand with breakage there can be no doubt that a seasonal breakage occurs. An average curve was plotted for the five years, 1915–1919 inclusive, on the basis of the number of replacements per month. Also for the same five years an average curve was run for the number of thunder storms per month in northern Ohio. Fig. 253 shows these two sets of curves.

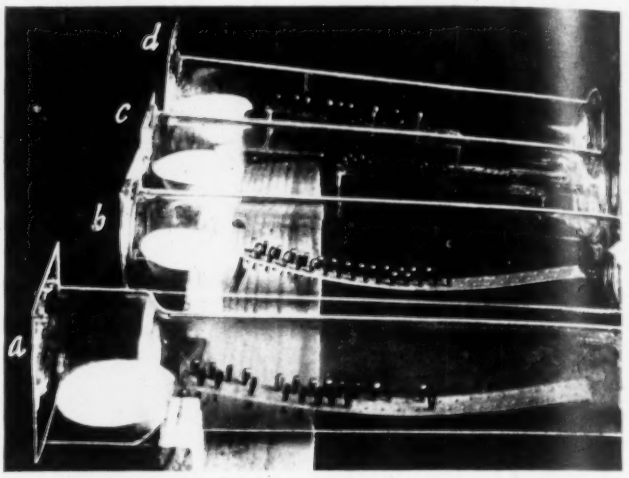

Fig. 252. Strips of watch springs were put into a state of strain by bending them into a U-shaped form. Rust enlarged the cracks in the surface of the steel springs and weakened them so that they broke. Rust developed easiest in water-filled jars.

A seasonal breakage is quite evident. In order to test the effect of moisture on the springs, metal strips carrying twenty or more strained pieces of watch spring were placed in tall glass cylinders laid on their sides as in Fig. 252. In alternate jars small dishes of water were placed and in the other small dishes containing phosphorus pentoxide.

The results of a number of tests are herewith given.

Exp. No.	Samples in each jar	Days under observation	No. broken in moist air	No. broken in dry air
1	22	7	11	0
2	28	52	17	0
3	30	41	10	0

These results are most convincing. As a further check some of the strained springs were coated with oil and the others left uncoated. Both sets were then placed in

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Fig. 253. Correlation between thunderstorms and breakage of watch springs.

an atmosphere of moist air and the results are recorded in the following table:

Exp. No.	Clean Samples	Oiled Samples	Days under Observation	No. broken Uncoated	No. broken Coated
1	16	16	33	3	0
2	15	15	12	15	7

Experiment 1 was made on a spring fresh from the factory, while experiment 2 was an old spring which had been lying around in the laboratory and showed rust spots before being oiled. The above experiments lend weight to the idea that watch spring breakage may be reduced by preventive treatment with oil. In every one of the broken springs it was observable that rust had formed along the line along which the break occurred.

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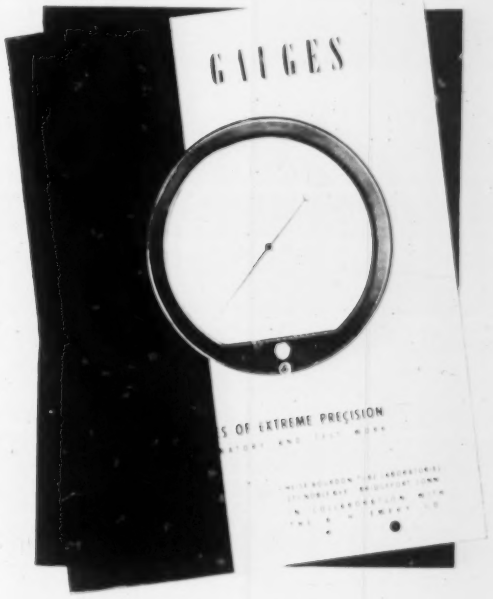

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Electric Circuits and Wave Filters (Second Edition). By A. T. STARR. Pitman Publishing Corp., New York, 1938. Cloth, 6 1/2 × 9 1/4 inches, xiv + 176 pages. Price $6.00.

The second edition of this British text is brought up to date by more than 100 pages of new material, contained in several new appendices describing a new method of filter design based on the lattice-type network, some recent developments in constant-resistance networks and filters, the theory and design of impedance-correcting networks, and the characteristics of filters using quartz crystals as elements.

Except for the added appendices, the book is identical with the first (1934) edition, beginning with a brief review of the mathematics pertinent to electric circuits and wave filters and with the fundamentals of line theory. Next the theory of electric circuits is presented, and the author includes acoustical and mechanical analogues and electro-acoustics. This is followed by a lengthy discussion of the design and characteristics of various types of resistances, coils and capacitors which are used as network and filter elements. Several chapters are then devoted to discussions of various kinds of two- and four-terminal networks and low-pass, high-pass, and band-pass wave filters. The text is concluded with descriptions of methods of calculation and measurement of filter performance and with a treatment of the response of networks to transients.

The book stresses the theory and characteristics of wave filters with only occasional references to their application. The author demonstrates his familiarity with the latter field, however, by his frequent references to the economics of filter design. Considering the large variety and number of topics treated, the volume is remarkably compact. The author's expositions are concise and to the point.

This reviewer's principal criticism of the book is the absence of numerical problems and illustrative examples. Most of the derivations are expressed in general algebraic terms. This should not detract from the value of the book as a reference work for those who specialize in this field, but it tends to make difficult reading for the student who does not have a knowledge of the numerical quantities involved in filter design.

W. O. OSBON, *Electro-Mech. Dir., Westinghouse Research Labs., East Pittsburgh, Pa.*

Chemical Spectroscopy. By WALLACE R. BRODE. John Wiley & Sons, New York, 1939. Cloth, 6 × 9 1/4 inches, xii + 491 pages; 36 plates (one in full color), 300 figures; 120 pages of tables. Price $6.00.

All those who have taught this subject for years without a text will welcome this book which "includes both the theoretical and the practical points of view, with the necessary charts and samples for most of the applications of methods now available." The student finds here details concerning the use of various types of instrument, the choice of a spectroscope for a particular purpose, as well as the characteristics of various sources which suit them to particular cases. The types and handling of photographic material, the plan of a laboratory, and the method of reporting observations are all considered. So, by use of the text and the ample and well-chosen references, a beginner can instruct himself in chemical spectroscopy. However, the book will be even more useful as a stimulating aid to teacher-student working together.

Absorption spectra and their analysis are more helpfully treated in this volume than in any other one known to the reviewer. The author directed the chemist to those parts of the book which will enable him to make spectrochemical reports with understanding. Tables of the most sensitive and of the strongest lines (chiefly of iron) are arranged both by elements and by wavelength. The spectrum of iron is shown in 35 plates covering the range 2,000 to 5,100 A.U. The wavelengths of the important lines of nearly all the chemical elements are indicated at the proper place beside this iron spectrum—an invaluable aid to the analyst. This book should be in every library of chemistry.

KELVIN BURNS, *Astronomer, Allegheny Observatory, Pittsburgh, Pa.*

Motion Picture Sound Engineering. RESEARCH COUNCIL, ACADEMY OF MOTION PICTURE ARTS AND SCIENCES. D. Van Nostrand Co., New York, 1938. Cloth, 6 × 9 1/4 inches, xviii + 348 pages. Price $6.00.

This book is a symposium of papers on studio sound recording and theatre sound reproducing equipment and practice given before classes sponsored by the Research Council. Its authors are prominent engineers of the motion picture industry and write with authority in their particular fields.

As indicated in the foreword, the book is lacking somewhat in continuity because of its many authors. It may, therefore, properly be classed as a sort of handbook on the subject of sound motion pictures.

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C. R. HANNA, *Mgr., Electro-Mech. Dept., Westinghouse Research Labs., East Pittsburgh, Pa.*

Practical Electric Metering. By M. F. ..., A. N. PRENTICE, H. E. BUCK, ... WRIGHT, R. V. KELCH, C. L. LUCAL, ... G. K. BERNHARD. John Wiley & Sons, New York, 1940. Cloth, 6 × 9¼ *inches*; viii ... pages. Price $2.75.

Though this book represents the joint ... apparently of seven authors, it is ... sense a symposium, but is a well ...ordinated textbook developing the sub-...ject in logical sequence, and containing ...tle or no overlapping of material. It ... based upon lessons from a school ...nducted by a large operating utility ...mpany" (The Ohio Power Company). "The purpose of the book is purely edu-...ational. The material herein is not ex-...pected to serve as a standard practice in ...making meter installations, but rather to ...be consulted as a textbook by metermen ...and others interested in meters in order ...that they may better understand the ...equipment used in their work."

Few books dealing with the subject of ...electrical measurement have so well suc-...ceeded in minimizing consideration of all ...instruments and testing devices not di-...rectly concerned with the one specialized ...branch—*metering*—to which the work is ...devoted. Only one *instrument*, the power ...factor meter, is treated in any way.

The work opens with a concise treat-...ment of Ohm's law and important funda-...mentals of the electric circuit; and the ...authors have shown remarkable consid-...eration for the reader in not overrating ...his academic attainments. For example, ...among the earlier paragraphs is inserted ...a brief treatment of the quadratic equa-...tion, something which many an engineer ...would appreciate in works catering to a ...supposedly more professional clientele ...than does this book.

Treatment of d-c and a-c principles, ...while thorough, is definitely restricted to ...those aspects which will be of direct and ...to the meter man; and a vast amount ...of superfluous material is thereby avoid-...ed. Vector analysis is carefully explained, ...and the relative utility of treatment of ...a-c problems by wave representation ...and by vectors made clear.

For a book dated 1940, the space de-...voted to the marked advances in braking ...magnets made possible by the use of ...modern alloys is somewhat disappoint-...ing; and the same criticism may be said ...to apply in the case of instrument trans-...formers and the improvement in their ...characteristics due to the utilization of ...new ferromagnetic materials.

The essential principles of both d-c ...and a-c meters, their characteristics, ...errors, and compensations, are thorough-...ly discussed, and remarkable ingenuity ...is shown in avoiding all reference to the ...products of specific manufacturers. Poly-...phase systems are clearly developed, and ...vector analyses of a-c circuits logically ...expanded into their embodiment in meter ...and in instrument transformer connec-...tions. The peculiarities of the current ...transformer are well pointed out, and ...the danger attending the opening of its ...secondary circuit explained and given ...due emphasis.

The metering of reactive volt-ampere-...hours and volt-ampere-hours, like that ...of other magnitudes, is treated essen-...tially on the basis of obtaining an in-...tegration, rather than an indication, or ...a record, and little, if any, consideration ...is given to conditions developing on an ...unbalanced load. Two forms of power ...factor meters are described and classi-...fied as "induction type and electrody-...namic type," reference to the moving ...iron or magnetic-vane class of instru-...ment under the former name appearing ...to be a misnomer.

From the relative space devoted to the ...treatment of classes of demand meters ...it is quite apparent that the authors ad-...vocate the *thermal*, rather than the *me-...chanical*, method of demand determina-...tion. The statement that "from the chart ...made by a graphic recording instrument ...the value of instantaneous peaks, the ...time and length of such peaks, the av-...erage value of loads and other charac-...teristics of the load may be obtained" is ...very well as far as it goes, but no mis-...giving is given as to the problems involved ...in obtaining such data in a form suit-...able for billing. While fewer than four ...pages are devoted to integrated demand ...meters, almost 24 pages are occupied ...with a discussion of lagged demand me-...ters, specifically the thermal wattmeter ...type. Though this presents probably ...the most comprehensive treatment of the ...principle of the thermal wattmeter yet ...published, it is unfortunate that so little ...effort has been made to segregate the ...two involved principles (measurement of ...watts by a thermal method, and the in-...troduction of an exponential time lag by ...means of thermal loading). No suggestion ...is made that this valuable method of po-...wer determination has any other use ...than in the measurement of demand. In-...cidentally, it is in this chapter that the ...authors make the only slip from their ...policy of not naming the maker of any ...metering device. In this section, as in ...those where magnetic materials are in-...volved, important developments announ-...ced within the past few years have ap-...parently not come to the attention of ...the authors.

An appendix covers the checking of ...wattmeter connections, including some ...valuable lessons in trigonometry, but ...this, as well as all other parts of the ...book, is based on the assumption that

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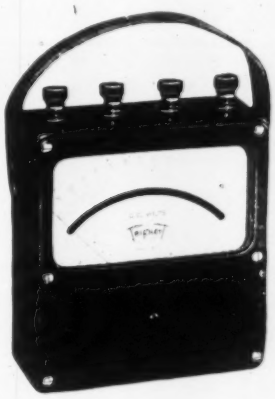
MODEL 625



Attractive Black Molded Case — Clear Readability — Long 4.58" Scale

Models 625 (DC—Moving Coil Type)—635 (AC—Movable Iron Vane Type) and 665 (Electrodynamometer Type) . . . new molded case portables, may be obtained with extreme sensitivity for laboratory use—as well as those for general commercial and industrial testing purposes. Have mirror scale and knife-edge pointer to assure quick, accurate readings. Scale length is 4.58"—Accuracy within 1%. Attractive black molded case, 6" x 5½" x 2½". Attached leather strap handle.

Another popular line of portables includes Models 725 (DC)—735 (AC). This popular style has a precision instrument with long 6" mirror scale. Oak case is 11" x 9" x 4".

Model 325 . 2.37" Scales—Models 325 (DC)—335 (AC) for laboratory, shop bench and special purposes. Tilting feature permits adjustment to any angle for accurate reading.

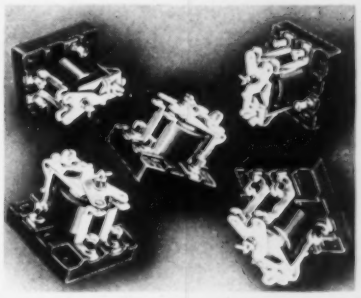
Model 525 . 3.50" Scale—Has mirror scale and knife edge pointer for extreme accuracy in reading.

To further meet the demand for portable instruments, Triplett has available handy instrument stands for 3" and 4" panel instruments; available with 2, 3, or 4 binding posts. Black wrinkle finish all metal case—sloping panel—4" x 4" x 3½".

Write for Catalog—Section 325 Harmon Drive

THE TRIPLETT ELECTRICAL INSTRUMENT CO.
Bluffton, Ohio

RELAYS
viewed from every angle



CRISP ACTION. The wiping action of fine silver to silver contacts keep them clean.

DEPENDABILITY. Contacts never stick or become pitted. Hence no failure.

DURABILITY. The combination of sound design and careful construction with sturdy parts gives unusually long life.

ECONOMY. Even though the construction is sturdy, fine workmanship makes easy action without undue current consumption.

The Ward Leonard Line comprises light, intermediate and heavy duty, sensitive, transfer, and thermal and motor-driven time delay types for every application. Send for bulletins describing items of interest to you.

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